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DOCTOR ARTHUR'S RUST WORK

FRED J. SEAVER

(WITH PLATE 14)

Dr. J. C. Arthur of Purdue University has just completed his monumental and long-looked-for work on the Uredinales in the North American Flora (except indices), the first part having been issued March 6, 1907, and the last part October 26, 1927. This entire work comprises 766 pages of text which has required twenty years for its publication, and half as much longer of continuous effort to compile. Probably no other piece of mycological work in America has been carried out so persistently, and, while some may differ as to the method of presentation, all mycologists will agree that he has brought together under one cover a vast amount of knowledge in this particular group which will be invaluable to coming generations, whether they may choose to follow his classification or not.

The work is based largely on his own collection of Uredinales housed in Purdue University, Agricultural Experiment Station, representing over 50,000 collections of rusts obtained from all parts of the world but chiefly from North America. This is probably the largest rust collection in America. Much time has also been spent on the rust collection of The New York Botanical Garden which has been arranged by him and his assistants to follow the treatment in the North American Flora. It represents the second largest collection of rusts in the country, with nearly 40,000 collections. He has not, however, confined his attention to these two collections but has studied in other

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large herbaria at home and abroad. He has made a number of trips to Europe in order to consult with Uredinologists of other countries.

Dr. Arthur is one of the oldest of American mycologists and an outstanding figure in that field, having more than two hundred and fifty titles to his credit. It has always been a satisfaction to collectors in out-of-the-way places to know that at least, their rust collections could be thoroughly worked over and the results submitted within a reasonable time. This is probably not true of any other large group of fungi. In this way the rusts of various islands of the West Indies and the countries of Central America have been recorded by him, although he himself has never visited any of them.

The writer's first intimate knowledge of Dr. Arthur's work was gained during the spring of 1903 while a student in the State University of Iowa, having been delegated by Professor T. H. Macbride to assist Dr. Arthur in his rust work for that season, at Purdue University. The ten weeks spent in Indiana were both profitable and interesting. Although not particularly interested in the rusts, I was much impressed by the methodical manner in which the culture work was conducted and the great care in handling all details connected with his rust herbarium. Since coming to The New York Botanical Garden in 1908 we have carried on an almost continuous correspondence and exchange of materials and to him I am indebted for the determination and publication of my Trinidad rusts under the title, "Uredinales Collected by Fred J. Seaver in Trinidad." Among the new species reported in this paper I am naturally proud of the one dedicated to me (*Puccinia Seaveriana*), a minute species occurring on the leaves of a composite tree.

Many other young mycologists have worked with him for longer or shorter periods and I am sure all of these and many others who have not been so intimately associated with him will join in commending Dr. Arthur for his present accomplishments as well as in wishing him still many years of active work in the field of research. We take pleasure in presenting at this time a photograph taken on his seventy-third birthday.

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TRILLIUM RUST [1]

M. F. Barrus

(With Plates 15 and 16)

An *Aecidium* on *Trillium recurvatum* was collected by A. B. Seymour in 1882 at Pine Hills, Union County, Illinois. Two years later this was described by Burrill (1) as *Aecidium Trillii* n. sp. No printed record of this *Trillium* rust has since appeared from Illinois and many years passed without any further reference to it anywhere. In 1907 it was found on *Trillium grandiflorum* at Taughannock Falls near Ithaca, N. Y., by H. H. Whetzel, M. B. Thomas, and the writer. Since that time it has been observed there nearly every year on both *T. grandiflorum* and *T. erectum*. House (2) reports finding it in 1923 on *T. erectum* and *T. undulatum* near Newcomb, Essex County, N. Y. A collection of an *Aecidium* on a plant labeled "*Trillium obovatum* Ledeb.," probably *T. kamtschatikum* Pall., was made by W. L. Kamarov on July 6, 1908, in Kamchatka and determined by W. A. Tranzschel to be *A. Trillii* Burrill. This collection was deposited in the Institutum crypotogamicum Horti Botanici Petropolitani. A specimen from this collection is in the Office of Mycology and Disease Survey of the Bureau of Plant Industry, Department of Agriculture, Washington, D. C. An examination of this specimen by the writer shows the rust to be identical with *A. Trillii* found at Taughannock Falls.

The prevalence and distribution of this rust as it occurs at Taughannock Falls has been studied from year to year since 1915 primarily with the hope of discovering the alternate host. Some years it has not been seen at all. Most years only a few rusted plants could be found, sometimes only one or two being

[1] The writer gratefully acknowledges the advice given by Professor H. H. Whetzel and the use of his notes on *Trillium* rust; the helpful suggestions extended by Doctors H. S. Jackson, F. D. Kern, and J. C. Arthur; the assistance of Mr. J. G. Horsfall in making spore measurements and spore germination tests; and the assistance of others in the preparation of this paper. The photographs used were made by Mr. W. R. Fisher.

located and those but slightly rusted, although both *Trillium erectum* and *T. grandiflorum* grow there profusely. But during three years, at least,—1915, 1922, and 1925—it was abundant on both species of *Trillium* within the particular area where it occurs, and the affected plants had from one to several lesions.

At Taughannock Falls, *Aecidium Trillii* had been confined to a particular area on the north side of the gorge. This area is about half way up the gorge from the lake to the falls and is near the foot of the path that leads to the top on that side. The affected plants do not occur within this area in exactly the same location year after year. In 1915 and 1922, plants affected with the rust were found abundantly at the base and sides of the slope but the limits of the area were not determined. In 1920 and 1921 they were confined to a space about 5 rods in its widest diameter, located on the slope facing south. Only twelve rusted plants were found in 1923 and twelve in 1924, and these were located within the same area. Since 1924 the location of the rusted area has been near by but on the slope facing to the southeast. In 1925 affected plants were discovered along the side of this slope and at its foot for a distance of 25 rods in a southeast and northwest direction, the area being top-shaped with its widest diameter on the side of the slope at the northwest. During 1926 and 1927 the rusted plants have been found only on the slope at the northwest end of this area. This slope is very steep, nearly 45°, and trilliums grow sparingly there, although near the foot where the slope is more gradual, *Trillium erectum* is abundant. Both species are very numerous on the flat at the bottom of the slope and at various places throughout the entire length of the gorge which is nearly a mile long. Yet at no time, since these observations have been made, have rusted plants been found elsewhere in the gorge nor has the rusted area been greater than 15 × 25 rods.

The lesions first appear after the plants have passed the peak of blooming. They have been first observed at Taughannock Falls during the latter half of May or the first half of June, depending on the season. During 1922, pycnia and immature aecia were found on May 14, which is earlier than in any other year. Within a week after the appearance of the pycnia, the

aecia may be open but sometimes it may be two or three weeks before they reach maturity. A secondary, more or less complete, ring of aecia may surround those first formed (PLATE 15, *A*), or there may be an extension of the spot in which aecia are produced. A light yellow zone surrounds the primary ring before the secondary ring appears and a similar zone may later surround the latter (PLATE 15, *B*). New spots were found on young plants and on green parts of older ones at a time when older spots had become dry and dead and these, apparently, were due to more recent infections.

The spots, before the aecia are mature, are lemon-yellow in color and vary in size, some being as much as 2 cm. in diameter. The pycnia, which have a bright red color, are scattered over the central area of the spot, in some cases only on the lower and in others on both the lower and upper surface of the leaf. The aecia then are pearly-white, cone-shaped projections occurring in a zone about the pycnia. The leaf tissue of the affected area is somewhat thicker than healthy tissue but is not materially distorted.

The description of *Aecidium Trillii* given by Burrill (**1**) and by Arthur (**3**) agrees well with the specimens under observation. Fresh specimens have pycnia with a distinctly red color when young. These are 83–100 μ wide and 76–92 μ high. The ostiolar filaments are 65–85 μ long and, near the apex, the agglutinated mass of filaments and pycniospores may become nearly as wide as the pycnium. The pycniospores are hyaline, ovoid to oblong bodies, about $2 \times 4\ \mu$ in diameter. The aeciospores are 12.6–23.4 $\times$ 14.4–25.2 μ, mostly 16.2–18 $\times$ 18 μ in diameter (PLATE 15, *C*). Fair to good germination of aeciospores was obtained within 24 hours when they were placed in distilled water on glass slides and kept at 15–20° C.

The uredinial stage of a rust on *Brachyelytrum erectum* (Schreb.) Beauv. was observed within the *Trillium* rust area at Taughannock Falls on July 4, 1922. Because of its location and because no rust had been reported on this grass, it was thought that it might be the alternate host of *Aecidium Trillii*. The rust was abundant on the grass growing among the rusted trilliums but not elsewhere. Later in the season telia were present in the

rusted lesions. During 1923 and 1924 this rust was not found. These were years when rust on the trilliums was scarce. Only four rusted stools of this grass were found during 1925 but these were severely affected. They were growing on the slope facing southeast which was the location of rusted trilliums that year. During 1926 only three stools of rusted grass were found, these being the same plants that were affected the year before. The only rusted trilliums found during 1926 were in the vicinity of these rusted gasss plants and on the slope below them. These same stools of grass, two young plants immediately adjoining, and two others, respectively 14 and 27 feet away, were the only ones affected by rust during 1927 and it was only in this vicinity that the *Trillium* rust occurred that year. A careful search of all trilliums and of *Brachyelytrum erectum* growing within the area at Taughannock where rusted trilliums had been found in past years, and in the surrounding area, was made during the summer and fall of 1927. The grass occurs mainly on the slope facing south, midway between the foot and head of the slope, and occupies an area of approximately 5 × 12 rods. This area coincides in part with the *Trillium* rust area but extends somewhat farther west. The *Trillium* rust area some years extends somewhat farther east and southeast (down the slope) than the area occupied by the grass. The grass is not particularly abundant, even within the *Trillium* rust area, as only about 200 stools or growing plants can be found. A few plants have been found along the slope above, but none at all on the floor of the gorge, where trilliums grow profusely, nor on the other slopes. The limitation of the distribution of *Trillium* rust largely to the area in which the grass occurs, and of the grass rust in any year to the particular location of rusted trilliums, as well as the occurrence of the grass rust only in years when *Trillium* rust is abundant or present, seemed to indicate a relationship between these rusts.

INOCULATION EXPERIMENTS

In the fall of 1922, rusted leaves of *Brachyelytrum erectum* were placed in wire cages for wintering and one plant was transplanted near some red and white trilliums in the writer's garden

at a place partly shaded by trees. The following spring, the wintered leaves were suspended over trillium plants placed in pots under bell jars on a greenhouse bench. Rusted leaves were also placed over trilliums growing in the garden which were then covered with bell jars. In no case was any infection of the trilliums obtained from these inoculations. The temperature during the inoculation period was very high and it was quite dry out-of-doors, although the greenhouse plants were kept wet. During 1923, there was very little infection on the trilliums at Taughannock.

As no rusted grass material could be located during 1923 and 1924, further attempts to inoculate trilliums were necessarily postponed until 1926. The previous autumn, rusted grass leaves had been collected and placed in a wire cage. One clump of rusted grass had been planted in a pot and placed in the garden near red and white trilliums. On May 2, rusted grass leaves were placed beneath and above other young white trilliums in the garden and the plants given half shade with a slotted cage. Still other trilliums were also similarly treated but were shaded only by trees. On the same day rusted grass leaves were placed on the upper surface of three white trilliums at Taughannock. A six-hour rain occurred during the afternoon of the following day. On May 18, two rust spots showing pycnia were observed on one white trillium inoculated in the garden. One of these spots never developed mature aecia. The other inoculated plants in the garden did not become affected. On May 23, each of the three white trilliums inoculated at Taughannock showed two spots. Only ten other rusted trilliums could be found at Taughannock during 1926.

Two red trilliums from the garden were transplanted to pots and placed in a cool greenhouse on May 4. Old rusted grass leaves were placed about their base and suspended from the top of a bell jar that was placed over them. The grass leaves and plants were well moistened. Three days later the bell jar was removed. On May 12, the leaves were densely spotted with pycnia on upper and lower surfaces. Pycnia were present on the sepals and on the upper end of the flower stalk. Mature aecia were observed on May 26.

One red trillium was inoculated on May 13 by suspending over it the rusted grass leaves used in the inoculation of May 4 and was then watered and covered with bell jar for three days. On May 24, two spots containing pycnia had developed on the leaves and, on June 2, mature aecia were observed.

On April 28, 1927, two red trilliums and three white ones, placed in pots and transferred from the garden to cool greenhouse, were inoculated by suspending over them old rusted grass leaves collected the previous autumn. They were well wet down and left covered with bell jars for four days. Pycnia were observed on the red trilliums on May 9. On May 13, a count showed 155 pycnial spots on the leaves of one plant and 79 on those of the other. One of the white trilliums showed but one spot and the others none. This does not indicate that the white trilliums showed resistance as the material used for inoculation had molded considerably. All the lesions were small (3 mm. in diameter or less), some scarcely distinguishable to the eye. The aecia were beginning to open on May 23 and their development continued on leaf veins and at apex of the stalk until the last of July, the tissue of the leaf-blades being brown and dry for the most part at that time.

The results of inoculations on *Brachyelytrum erectum* with aeciospores from *Trillium* were not so successful. From 37 inoculations made in 15 series at 12 different times from 1925 to 1927, infection took place in only three cases. Observations were not made of the time when the first evidence of infection occurred. When, on May 24, 1925, three rusted white trilliums, obtained at Taughannock, were planted near grass which had been transplanted to the garden the year before, infection took place some time during the summer, for numerous telia were present on the leaves especially on the lower ones. No infection occurred on the grass, obtained at the same time as the other, and which was growing in another part of the garden. When, on June 11 of the same year, aecia on red trillium were rubbed against the wet leaves of the grass which was then placed under a bell jar at 15° C. for 24 hours and then in an inoculation chamber where the temperature varied from 18–24° C., several uredinia appeared on one leaf by July 26. None occurred on check

plants treated similarly except not inoculated. When grass in another pot was inoculated on June 15, 1926, with aeciospores from red and from white trilliums in the same manner and with the same treatment as with the inoculation of June 11, several uredinia were observed on one leaf on July 19. Only a few inoculations were made during 1926 and 1927, as inoculum was scarce, and none of them resulted in infections.

Inoculations of *Brachyelytrum erectum* with urediniospores were likewise not very successful. Of 5 inoculations made in 1925 and 1 in 1927, only two resulted in infections. One made on July 28, 1925, by brushing urediniospores, obtained from the grass inoculated with aeciospores on June 11, and then placed in inoculation chamber for 5 days, showed 32 sori on 17 leaves on October 2. Of these sori, 18 were telia. One plant inoculated August 3, 1925, in the same manner and having the same treatment as the other, showed 1 uredinium on September 11 but no others developed. Check plants did not develop any rust.

Undoubtedly many of the unsuccessful attempts at securing infection in the above-mentioned experiments were due to improper attention to details. Necessary and frequent absences of the writer from Ithaca also prevented many observations of the inoculated plants from being made.

OBSERVATIONS AND CONCLUSIONS

The rust on *Brachyelytrum erectum* usually occurs most abundantly on the leaves of the lower part of the plant, the upper two or three often being free from rust spots. The apical end of the leaf is, as a rule, most severely affected but spots may occur over any part of the upper surface (PLATE 16, *A* and *B*). The lower leaves become quite generally covered with sori which may even appear on the sheath.

On the upper surface the rusted areas are somewhat elongated, with a color varying from clay to dark olive buff. Dark spots within these areas indicate the location of sori beneath. When sori are numerous, the leaf tissue between also becomes discolored. By the time telia are produced, the tissue about them has died. The apical end of badly affected leaves may be brown and dead by late summer.

Urediniospores germinate readily in distilled water at 15° C. within 24 hours. Teliospores do not germinate readily. Although tests were made from October to May, March 30 was the earliest date at which germination took place. The most abundant germination was secured in May. A four-celled promycelium, about $7 \times 60\ \mu$, having four sporidia, developed within 24 hours.

This rust resembles very closely the one described by Halsted (**4**) as *Uromyces digitatus* occurring on *Leersia virginica* Willd. and later named *Uromyces Halstedii* by De-Toni (**5**). The principal difference seems to be, according to H. S. Jackson,[2] that this *Uromyces* has 2–3 slightly sub-equatorial pores in the urediniospores (PLATE 16, *C*) as compared to the 3–4 equatorial pores in *Uromyces Halstedii* described by Arthur (**6**). The telia are slightly wider and the epidermal covering less persistent. Also the digitate projections of the teliospores (PLATE 16, *D*) are longer, 4–8 μ, than those of *Uromyces Halstedii*. These differences do not seem to be sufficient for the constitution of a new species. It seems more logical to consider the rust on *Brachyelytrum erectum* as *Uromyces Halstedii* De-Toni. Should inoculation of Leersia with the aeciospores from *Trillium* or with the urediniospores of *Uromyces Halstedii* give negative results, it might be held to be a physiological race. No aecial host for this rust has previously been recorded nor has it been reported earlier as occurring on any grass host other than *Leersia virginica* Willd. and *L. oryzoides* (L.) Sw. On the former it has been found in Alabama, Iowa, Louisiana, Maryland, Wisconsin; and on the latter in Delaware, South Dakota, Texas and Wisconsin. It has also been reported by Ito (**8** and **9**) from Japan on *Leersia oryzoides* (L.) Sw., var. *japonica* Hack.

The synonymy appears to be as follows:

Aecidium Trillii Burrill, Bot. Gaz. **9**: 190. 1884.

Uromyces digitatus Halsted, Jour. Myc. **3**: 138. 1887. Not *U. digitatus* Wint. 1886.

Uromyces Halstedii De-Toni, in Sacc. Syll. Fung. **7**: 557. 1888.

Uromyces Halstedii Ludw., Bot. Centr. **37**: 120. 1889.

[2] Letter of Sept. 29, 1927.

Caeomurus Halstedii Kuntze, Rev. Gen. **3**: 450. 1898.
Uromyces ovalis Diet., Bot. Jahrb. **37**: 97. 1905.
Nigredo digitata Arth., Result. Sci. Congr. Bot. Vienna 343. 1906.
Nigredo Halstedii Arth., North Am. Fl. **7**: 226. 1912.
Ontotelium digitatum Sydow, Ann. Myc. **19**: 174. 1921.
Dicaeoma Majanthae (Schum.) Arth., New York State Mus. Bull. **266**: 43. 1925.

The scarcity of this rust on *Trillium* and *Brachyelytrum* arouses interest in factors that may be responsible. This rust apparently depends upon the two hosts for the completion of its life cycle. There is no indication that the urediniospores can be carried through the winter. Telia have been found within two weeks after the appearance of uredinia and no uredinia have been observed late in the fall. The two hosts may not, in most places, be growing in sufficient proximity to each other to permit the continued existence of the rust after being introduced. The fungus may be quite sensitive to environmental conditions so that periods when conditions are at all favorable may be relatively short during most seasons, or favorable locations where the two hosts occur may be few in number. The aeciospores may be short lived although they are produced during a period of a month or more. At Taughannock Falls the fruiting bodies of *Darluca filum* (Biv.) Cast. have been observed among the aecia and especially in the uredinial and telial sori. This fungus is known to be parasitic to Uredineae and may seriously interfere with the development of this *Uromyces*. Gall midge larvae, determined by New York State Entomologist, E. P. Felt,[3] to belong in the family Itonididae, possibly a species of *Mycodiplosis*, were commonly present among the aecia, supposedly feeding on the aeciospores. During 1922, they were very abundant, each spot having one or more of these larvae present. These mycophagous insects are capable of diminishing greatly the number of aeciospores available for inoculation. From observations made at Taughannock Falls it would seem that, when the two hosts occur near each other

[3] Letter of July 19, 1927.

and the rust fungus has become established on them, no one of these factors is all-important.

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DESCRIPTION OF PLATES

PLATE 15

Uromyces Halstedii on *Trillium* sp.

A. Aecial lesions on lower surface of leaves of *Trillium grandiflorum*. Natural size. Photographed June 5, 1925.

B. Aecial lesion on young *Trillium* leaf, showing aecia, pycnia, and discolored zone about aecial ring. × 3. Photographed June 15, 1924.

C. Aeciospores from *Trillium erectum*. × 389. Photographed June 11, 1924.

PLATE 16

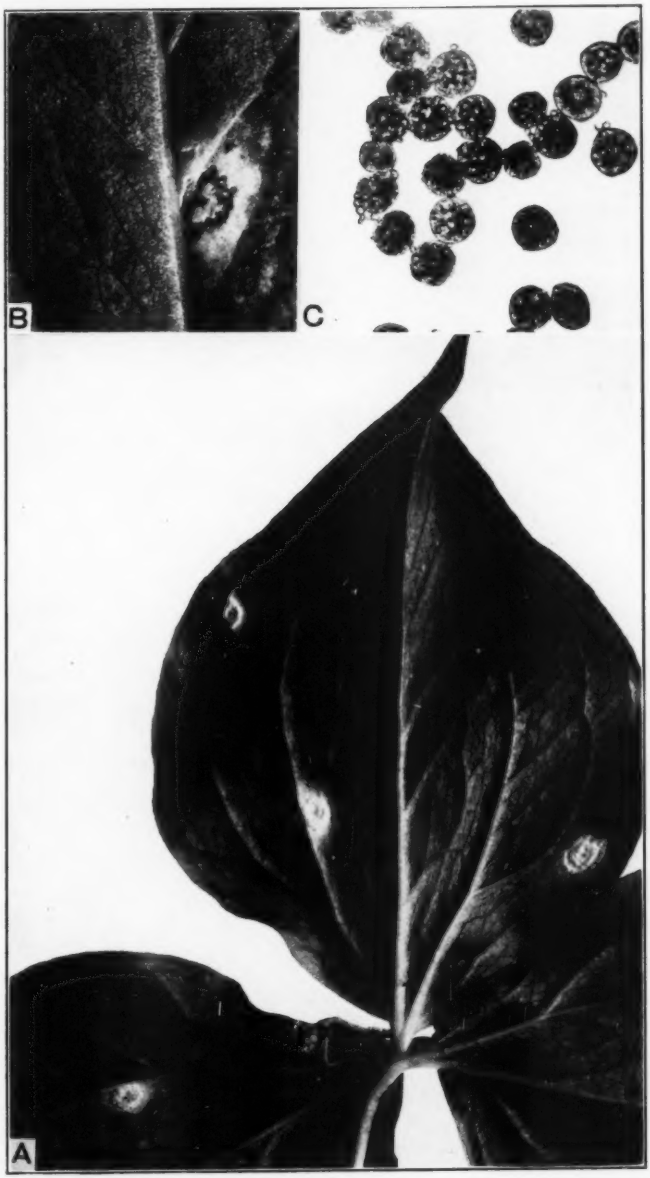
Uromyces Halstedii on *Brachyelytrum erectum*

A. Apical half of leaf showing uredinial lesions. × 2.5. Photographed Aug. 7, 1927.

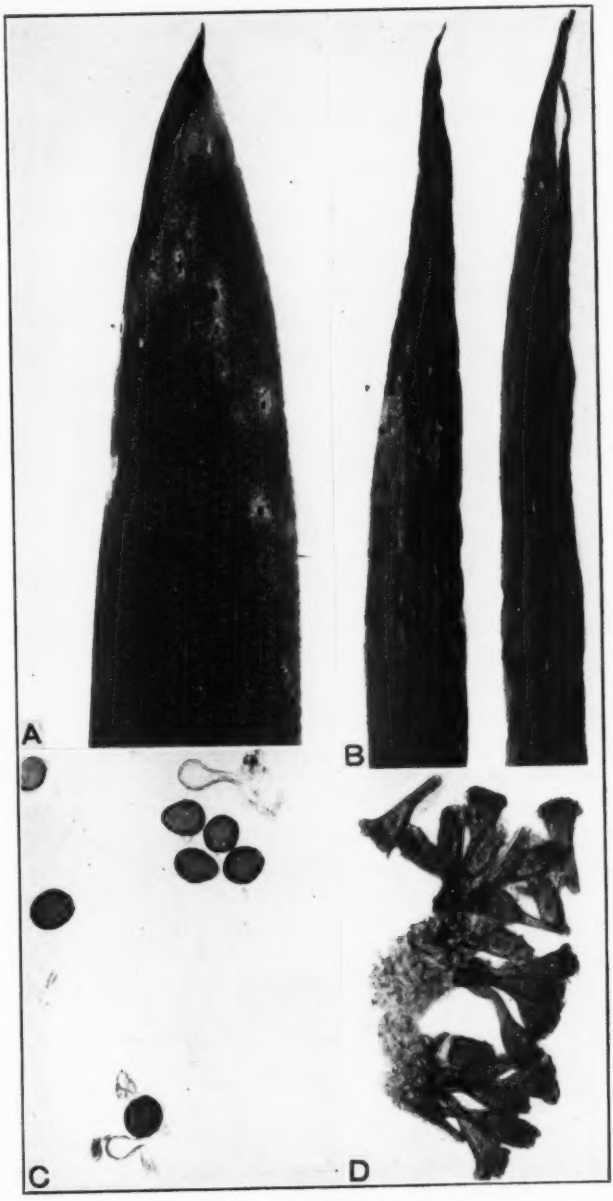
B. Leaves showing telia and the effect of the rust on leaf tissue. Natural size. Photographed Oct. 15, 1925.

C. Urediniospores and paraphyses. × 275. Photographed July 4, 1922.

D. Cluster of teliospores. The digitate projections are not well illustrated. × 275. Photographed Oct. 15, 1925.



UROMYCES HALSTEDII



UROMYCES HALSTEDII

THE MONILIOID SPECIES OF SCLEROTINIA

EDWIN E. HONEY

(WITH PLATES 17–19 AND 4 TEXT FIGURES)

During the past several years the writer has been engaged in a monographic study of that section of the genus *Sclerotinia* whose members possess a monilioid conidial stage. As the study progressed it became more and more essential to have as a starting point a clearer understanding of related forms not only within the genus *Sclerotinia* as recognized at present but also within related genera. This has led to the following critical remarks concerning the generic concepts in *Ciboria*, *Sclerotinia*, *Rutstroemia* and *Stromatinia* and to the establishment in this paper of the new genus *Monilinia*.

HISTORICAL REVIEW

Much confusion exists regarding the true concept not only of the genus *Sclerotinia* but also of several closely related genera. The following historical review is an attempt to set forth in chronological sequence these various generic concepts and to evaluate them as well as possible under the present unsatisfactory nomenclatorial situation. In order to do this it has been necessary to designate the type species for several genera in cases where the authors of such genera have not done so. This is a task which would best be assumed by a committee of authorities for this particular group of fungi, and the decisions made are, therefore, offered merely as one worker's opinion on the matter.

The genus *Sclerotinia* Fuckel was first proposed by Karl Wilhelm Gottlieb Leopold Fuckel (**1869**: 330) in his "Symbolae Mycologicae" to include five species: *S. Candolleana* (Lév.), *S. Fuckeliana* (DeBary), *S. Libertiana* Fuckel, *S. tuberosa* (Hedw.) and *S. baccata* nov. sp. The genus was limited to fungi with rather small, long stipitate, smooth, more or less infundibuliform, fleshy, marginated especially when expanded, apothecia, which rise from a sclerotium. The cups of the

apothecia are lined by a hymenium of filiform paraphyses and elongate asci containing eight, one-celled, oblong to elliptical, hyaline spores. The species are terrestrial and vernal.

Fuckel, in the above mentioned publication, removed the first four species listed from the genus *Peziza* and added the fifth as a newly described species. Later authorities listed this fifth newly described species of Fuckel as a member of the genus *Sarcoscypha*, a genus created by Fries in 1822, but the first four are still retained in *Sclerotinia*. Fuckel did not designate a type species for *Sclerotinia;* however, by virtue of being the first binomial mentioned (Fuckel **1869**: 330), *S. Candolleana* (Lév.) Fuckel becomes the type species of the genus. No illustrations were cited or given by Fuckel, but reference was given to exsiccatae. This species appears to be widespread in its distribution and has recently been reported by Wilson and Waldie (**1927**) as the cause of a serious oak leaf disease in Scotland and England.

The genus *Ciboria* was erected by Fuckel in the same publication (**1869**: 311) in which he first suggested the genus *Sclerotinia* (**1869**: 330), namely, his "Symbolae Mycologicae." The genus included seven species divided into two groups: the spring forms (Vernales) and the autumn forms (Autumnales). The species, listed in the order in which Fuckel gave them were as follows: (*a*) Vernales: *C. Caucus* (Reb.), *C. amentacea* (Balb.), *C. bolaris* (Batsch), and *C. ciliatospora* nov. sp.; (*b*) Autumnales: *C. rhizophila* Fuckel, *C. tremellosa* nov. sp. and *C. firma* (Pers.). Fuckel did not designate a type species; yet, because it is the first binomial species listed under the genus *Ciboria*, and because this is further supported by citations to illustrations, *C. Caucus* (Reb.) Fuckel is chosen as the type species for the genus *Ciboria* Fuckel. It is a species occurring upon the male catkins of *Populus tremula* L. and *P. alba* L. and it is said to be closely similar to but distinct from *C. amentacea* (Balk.) Fuckel. The genus, as suggested by Fuckel, included medium-sized, long stipitate fungi with a waxy smooth or pulverous surface, disk-shaped and marginated and arising from twigs or grass (apparently not from a sclerotium as a sclerotium is not mentioned). The hymenium consists of paraphyses and elongate asci con-

taining eight oblong-ovate one-celled hyaline spores. In Karsten's publication of the same year, *Ciboria amentacea* (Balb.) and *C. firma* (Pers.) of Fuckel were placed in section V, Phialea of the old genus *Peziza*, the other five species used by Fuckel in the erection of the genus *Ciboria* not being listed.

As is also true in the case of *Sclerotinia*, Karsten, in his "Mycologia Fennica" two years later (**1871**), did not recognize the genus *Ciboria*, but placed the species suggested by Fuckel (**1869**) for *Ciboria* either in his genus *Rutstroemia* or did not list them. Karsten, who published his "Monographia Pezizarum fennicarum" in the same year (**1869**) that Fuckel created the genus *Sclerotinia*, divided the old genus *Peziza* into twenty-five sections. In section V, Phialea, Karsten recorded two of the species, *Peziza tuberosa* (Hedw.) Bull. and *Peziza Sclerotiorum* Lib. (= *S. Libertiana* Fuckel), which Fuckel included in his new genus *Sclerotinia*. Two years later Karsten, in his "Monographia Fennica" (**1871**), did not recognize the genus *Sclerotinia* but created, among many others, the new genus *Rutstroemia* (p. 105). Under this new genus were listed seven species: *R. bulgarioides* (Rab.) Karst., *R. tuberosa* (Bull.) Karst., *R. amentacea* (Balb.) Karst., *R. homocarpa* Karst., *R. Curreyana* (Berk.) Karst., *R. macilenta* Karst., and *R. firma* (Pers.) Karst. respectively. Since no type species was designated, *Rutstroemia bulgarioides*, the first binomial species named, becomes the type species. Karsten gave citation to exsiccatae for this species. The genus was described as possessing elongate stipitate, glabrate apothecia, cup-like to infundibuliform in shape and somewhat closed at first, in many cases arising from a sclerotium. The hymenium was composed of cylindrical asci containing eight oblong ellipsoid or ovoid one-celled, nonguttulate spores, very rarely with slight false septation, and filiform paraphyses slightly curved at the ends. This genus included large or medium-sized fungi, of a pale brownish or sooty color.

In 1885 Karsten published his "Revisio monographia atque Synopsis ascomycetum in Fennia hucusque detectorum," in which he discarded his genus *Rutstroemia* stating that it was synonymous in part with *Sclerotinia* Fuckel (p. 123) and *Ciboria* Fuckel (p. 143), which he here recognized for the first time.

The type species of the genus *Rutstroemia* as suggested by Karsten (**1871**: 105), namely *Rutstroemia bulgarioides* (Rab.) Karst. was placed in his "Revisio Monographica" (**1885**: 124), in the genus *Chlorosplenium* Fries, it being a synonym of *C. lividum* (Alb. & Schw.) Karst. Under the genus *Sclerotinia* Fuckel (p. 123–124), Karsten listed four species occurring in Finland: *S. tuberosa* (Hedw.) Fuckel, *S. Libertiana* Fuckel, *S. Curreyana* (Berk.) Karst., and *S. adusta* Karst. respectively. The synonymy given here also shows that all four species had previously been placed by Karsten in his genus *Rutstroemia* which he here discarded. In this same paper, Karsten placed one species (occurring in Finland), *C. firma* (Pers.) Fuckel, which had also been included originally under his genus *Rutstroemia*, in the genus *Ciboria* of Fuckel.

Summarizing the above data we find the two genera, *Ciboria* and *Sclerotinia*, established by Fuckel, the only difference being in the origin of the apothecia from sclerotia (true sclerotia) in the case of *Sclerotinia* and the entire absence of sclerotia in the case of *Ciboria*. Thus far, all the species included in the genus *Sclerotinia* arise from a sclerotium composed entirely of fungous tissue and of a more or less definite size and shape. None of the fruit or tissue inhabiting pseudosclerotial forms have as yet been included in this genus. The genus *Rutstroemia* is apparently nonvalid but is synonymous in part with *Sclerotinia* and in part with *Ciboria*.

The next work of importance on the Discomycetes, that of Saccardo, "Conspectus generum Discomycetum hucusque cognitorum" (**1884**), subdivided the families on the basis of color, form and degree of septation of the spores. A few large genera with a number of subgenera were adopted. *Sclerotinia* Fuckel (= *Rutstroemia* Karst. *pro parte*) was given generic rank (**1884**: 216) with *S. tuberosa* (Hedw.) Fuckel cited as representative in the Hyalosporae Sacc. of the group Pezizeae Fuckel. Saccardo stated that the apothecia arose from sclerotia. *Ciboria* Fuckel (= *Rutstroemia* Karst. *pro parte*) was placed in the Hyalosporae Sacc. of the group Dermateae Fries (**1884**: 248). *Rutstroemia* Karst. was mentioned only as synonymous in part with *Ciboria* and in part with *Sclerotinia*. Five years later Saccardo published

on the Discomycetes in his "Sylloge Fungorum" (**1889**) and while basing his treatment of them on the "Conspectus" (**1884**), nevertheless he drew generic limits more closely, raised many subgenera of the "Conspectus" to generic rank and added new genera. In the "Sylloge Fungorum," *Sclerotinia* Fuckel (**1889**: 195) and *Ciboria* Fuckel (**1889**: 201) were given generic rank, *Rustroemia* Karst. being cited as synonymous. Karsten's type for the genus *Rutstroemia*, *R. bulgarioides* (Rab.) Karst. was recognized as synonymous with *Chlorosplenium lividium* (Alb. & Schw.) Karst. (**1889**: 319), apparently following Karsten, as above mentioned, in his "Revisio Monographica" (**1885**).

In 1885 Boudier published a preliminary paper, "Nouvelle classification naturelle des Discomycetes charnus," in which he endeavored to group in a natural manner the species studied by him in the fresh state. In this paper (**1885**: 115–116) Boudier recognized the genus *Ciboria* Fuckel and subdivided it into three subgenera as follows:

(1) Subgenus *Sclerotinia* (Fuckel) Boud., apothecia arising from a sclerotium, with *P. tuberosa* Hedw., *subularis* Bull., *Duriaeana* Tul. and *Curreyana* Berk., listed in this sequence.

(2) Subgenus *Stromatinia* Boud., apothecia arising from an effuse stroma, with *P. Rapulum* Bull. listed first and then *pseudotuberosa* Rehm as representatives.

(3) Subgenus *Ciboria* (Fuckel) Boud., apothecia arising from neither an apparent stroma nor a sclerotium for *P. Caucus* Reben. and *amentacea* Balb.

In 1907 Boudier published his work entitled "Histoire et Classification des Discomycetes d'Europe." The subgenera *Ciboria*, *Sclerotinia*, and *Stromatinia* of his earlier work (**1885**: 115–116) were here given generic rank, the three genera composing the tribe Ciborieae. Boudier recognized *Ciboria* Fuckel and *Sclerotinia* Fuckel in practically the same sense that Fuckel originally described them; however, he defined them somewhat more carefully. The characters of the asci and paraphyses are the same in all three genera: *Ciboria* Fuckel, *Sclerotinia* Fuckel and *Stromatinia* Boudier. *Ciboria* possesses ovoid nonseptate spores; the apothecia arise from dead twigs without trace of stroma or sclerotium. *Sclerotinia* possesses ovoid simple, guttu-

lated spores, rarely septate; the apothecia arising from a sclerotium. *Stromatinia* resembles *Ciboria* and *Sclerotinia* in the character of the apothecium, but is distinguished by the origin of the apothecium from a stroma which covers the organs on which it develops, but which is not differentiated into a sclerotium. This stroma may be white when it is internal, or black when spread over the surface. The species included in *Stromatinia* occur mostly on grains or fruits. The genus *Rutstroemia* Karst. was not mentioned by Boudier, but he included the type of the genus, *Rutstroemia bulgarioides* (Rab.) Karst. (= *Chlorosplenium lividum* (Alb. & Schw.) Karst.) in the genus *Ciboria* as *Ciboria livida* Alb. & Schw. *Ciboria Caucus* (Reb.) Fuckel, the type species of *Ciboria* Fuckel, as would be expected, was here placed in *Ciboria*, it being the first species listed. *Sclerotinia Candolleana* Lév. as well as *S. tuberosa* Hedw., *S. Libertiana* Fuckel, *S. Curreyana* Berk., *S. Duriaeana* Tul. and others with a true sclerotium were listed under *Sclerotinia*. The type species for the genus *Stromatinia* Boud. would appear to be *Stromatinia Rapulum* (Bull.) Boud. (= *Geopyxis Rapulum* Bull.). This fungus forms its black stroma on the rhizomes of its host plant similar to *Stromatinia Paridis* Boud., the second species listed here by Boudier. It was the first species listed by Boudier (**1907**: 108) who gave citations to illustrations and to previous Latin description by Saccardo, in which Saccardo published this species under the name *Geopyxis Rapulum* Bull. Thus we see Boudier transferred *G. Rapulum* Bull. from the genus *Geopyxis* Pers. and apparently used it as the type of the genus *Stromatinia* Boud.

In 1887 William Phillips published his "Manual of the British Discomycetes" in which he divided the group Pezizae into two series, Nudae and Vestitae, on the basis of the external features of the apothecium. *Sclerotinia* Fuckel and *Ciboria* Fuckel were here arranged as subgenera of the genus *Hymenoscypha* Fries in Series I, Nudae. The subgenus *Sclerotinia* was described as possessing long-stemmed apothecia arising from sclerotia. The following species were included in this subgenus: *H. tuberosa* (Bull.) (= *Sclerotinia tuberosa* Fuckel), *H. Candolleana* (Lév.) (= *S. Candolleana*), *H. sclerotiorum* (Lib.) (= *S. Libertiana*

Fuckel), *H. Duriaeana* (Tul.) (= *S. Duriaeana* Tul.), *H. filipes* Phill. (= *S. filipes* Phill.), *H. Curreyana* (Berk.) (= *S. Curreyana* (Berk.) Karst.) and *H. ciborioides*. It will be seen from this list that only species of *Sclerotinia* possessing a true sclerotium were included in this list. Phillips distinguished *Ciboria* Fuckel from *Sclerotinia* Fuckel by the character of its not rising from a manifest sclerotium. Eleven species were included in *Ciboria*. M. C. Cooke in his "Handbook of Australian Fungi" (**1892**: 263) listed one species each for *Sclerotinia* and *Ciboria*, evidently following the example of Saccardo in his "Sylloge Fungorum" (**1889**). Rehm (**1887–1894**) in "Rabenhorst's Kryptogamen-Flora" divided the family Helotiaceae into two subfamilies, the first of which was divided into four tribes, Pezizelleae, Cyathoideae, Hymenoscypheae and Sclerotieae. The tribe Cyathoideae was again subdivided into two subtribes, one of which was Ciborieae. It was in this group, Ciborieae, that Rehm gave recognition to *Ciboria* and *Rutstroemia* and *Chlorosplenium* which he separated by the following key.

Apothecia upon highly colored substratum.
  Spores one-celled ..... *Chlorosplenium.*
Apothecia upon scarcely colored substratum.
  Spores one-celled ..... *Ciboria.*
  Spores by septation finally two- to four-celled ..... *Rutstroemia.*

Rehm included here *C. Caucus* (Rebent.), the type species for *Ciboria* as first used by Fuckel, and his limits to the genus were quite similar to those of Fuckel. *Rutstroemia*, as first described by Karsten, has here been modified to include but one of the species originally included in the genus by Karsten. Rehm must have used *Rutstroemia firma* (Pers.) Karst. as the type in his conception of the genus. He stated that the spores were elliptical, or spindle-shaped, at first unicellular, later becoming two to four-celled, due to septation. These characteristics along with that of the commonly colored tips of the paraphyses formed the principal distinction between his concept of the genera *Ciboria* and *Rutstroemia*. The type of *Rutstroemia* Karst. (Karsten, **1871**: 105), *R. bulgarioides* (Rab.) Karst. (= *Chlorosplenium lividum* (Alb. & Schw.) Karst.) was placed by Rehm in the Bulgariaceae in the genus *Ombrophila* as *O. strobilina*

(Alb. & Schw.) Rehm. From these data it would appear that the genus *Rutstroemia* Karst. (*pro parte*) as used by Rehm is not a good genus, as the species, *R. bulgarioides* (Alb. & Schw.) Karst., was admitted by Rehm to belong to an entirely different group. Applying the principle of types, if the distinction which Rehm made, namely, of spore shape and septation and the generally occurring coloration of the tips of the paraphyses, is worthy of separating these species from *Ciboria*, it would then seem necessary to apply a new name to this genus rather than that of *Rutstroemia* Karst. Durand (**1900**: 492) has apparently preferred to accept the genus *Rutstroemia* Karst. as emended by Rehm.

Sclerotinia was the only genus included in the tribe Sclerotieae by Rehm (**1887–1894**: 800–824). Rehm divides the genus *Sclerotinia* into two subgenera: I. *Stromatinia* Boud. restricting it to those species in which the sclerotia were formed within fruits (**1887–1894**: 804), and II. *Eusclerotinia*, where the sclerotia were embedded in the tissues of stems or leaves. All the monilioid species of *Sclerotinia* known to Rehm were described under the subgenus *Stromatinia* (Boud.). Rehm described in this tribe, in the following sequence: *Sclerotinia Urnula* (Weimn.) Rehm, *S. Oxycocci* Wor., *S. Rhododendri* Fischer, *S. baccarum* (Schröt.), *S. megalospora* Wor., *S. Padi* Wor., *S. Aucupariae* Ludw., *S. Cerasi* Wor., *S. Mespili* Wor., *S. pseudotuberosa* (Rehm), and *S. Juglandis* (Preuss.). *Sclerotinia Candolleana* (Lév.) Fuckel, type of the genus *Sclerotinia* Fuckel, as well as *S. tuberosa* (Hedw.), *S. Libertiana* Fuckel, and others with true sclerotia, was listed in the subgenus *Eusclerotinia*. In addition to these two subgenera Rehm gave two doubtful species, *S. Rapulum* (Bull.) and *S. Tuba*. *Sclerotinia Rapulum* was the type species of the genus *Stromatinia* and the removal of this species from that subgenus would cast doubt on the validity of the use of the name *Stromatinia*. It should be noted that Rehm's criterion for separating these two subgenera was not on the morphology of the fungi involved but on the part or organ of the host affected.

Schröter (**1893**), in Cohn's "Kryptogamen-Flora von Schlesien," recognized for the most part the same families in the Pezizineae as Rehm (**1887–1894**). Schröter, however, did not

recognize the genus *Rutstroemia*, citing certain species of this genus, given by Rehm (**1887–1894**: 763–769), as synonyms of *Ciboria*. He also listed certain species at first included by Karsten (**1871**) in *Rutstroemia* Karsten as synonyms of *Sclerotinia*. Doubtless, Schröter either did not believe that septation of the ascospores was a good generic character or he recognized the nonvalidity of the genus *Rutstroemia* or he held both views. At least he did not separate the species possessing unicellular ascospores from those with multicellular ascospores. His description of the genus *Ciboria* Fuckel (**1893**: 60) stated that the ascospores were ellipsoidal, or ellipsoidal-spindle-shaped, one-celled, often at maturity becoming more than one-celled due to septation. Schröter described the genus *Sclerotinia* as possessing one-celled ascospores and separated *Sclerotinia* from *Ciboria* by the fact that it arose from a sclerotium, a structure which was lacking in *Ciboria*. Thus it appears that Schröter has given more nearly Fuckel's original limits to the genera *Sclerotinia* and *Ciboria*, which were also those eventually adopted by Karsten (**1885**), Phillips (**1887**), and Saccardo (**1889**).

Like Rehm, Schröter (**1893**: 63–67) divided the genus *Sclerotinia* into two groups: (*a*) Sclerotia developed on leaves and stems, which included *S. Candolleana* Lév., *S. sclerotiorum* (Lib.) and others with true sclerotia, (*b*) Sclerotia developed in fruits which included *S. baccarum* Schröter and other monilioid species of *Sclerotinia*. *Rutstroemia bulgarioides* Karst., the type of the genus *Rutstroemia* Karst., was placed in the genus *Ombrophila* Fries, as *O. strobilina*, which was the same disposition of it as that made by Rehm (**1887–1894**: 482).

In 1894 Schröter began to write the Discomycetes for Engler and Prantl, but on account of his death, Lindau continued the work along the same general outline that Schröter had initiated. The treatment of the genera of the Pezizaceae by Lindau seems to be closer to Rehm's than to Schröter's earlier treatise (**1887–1894**). Lindau used the same key as that used by Rehm to separate the genera *Chlorosplenium*, *Ciboria*, and *Rutstroemia* and he also used the same character, presence of sclerotia, to separate *Sclerotinia* from this group of three genera. The limits of *Ciboria* Fuckel and *Rutstroemia* Karst., as well as the sub-

division of the genus *Sclerotinia* Fuckel into two subgenera: (1) *Stromatinia*, and (2) *Eusclerotinia*, were the same as those of Rehm (**1887–1894**). Furthermore, Lindau, like Rehm (**1887–1894**: 482), listed *Rutstroemia bulgarioides* Karst. (= *O. strobilina* (Alb. & Schw.) Rehm) under the genus *Ombrophila* Fries. It is apparent that while both Rehm (**1887–1894**) and Lindau (**1896**: 197–199) have used the name *Stromatinia* as a subgenus they have altered the original concept of Boudier. The basis on which these authors made the division of the genus *Sclerotinia* does not appear to be a logical one, nor does it necessarily show the natural phylogenetic relationship.

Elias J. Durand published a paper on "The classification of the fleshy Pezizineae with reference to the structural characters illustrating the basis of their division into families" in 1900. It is sufficient to mention here that Durand recognized the genus *Rutstroemia*, making the primary basis of its separation from *Ciboria* and *Sclerotinia* on the septation of the ascospores, in this respect following Rehm and Lindau. Whether Durand placed *Rutstroemia bulgarioides* (Rab.) Karst., the type of *Rutstroemia*, in the genus *Ombrophila* as Rehm did, or retained it in *Rutstroemia* cannot be ascertained from his paper, but it is very likely that he followed Rehm in this regard. *Ciboria* was separated from *Sclerotinia* on the absence of a sclerotium.

DISCUSSION

It is the purpose of this historical review to determine the present status of the genera herein mentioned. At the present time the situation in respect to codes of nomenclature which might be followed, is more or less in a state of chaos. It is generally felt that the international code should be revised; but, on the other hand, it is not felt that the American code is entirely satisfactory. Thus it seems best to follow a somewhat middle ground. For that reason the international code is followed, but recognition of the principle of types is also applied. As has been stated (Hitchcock, **1922**, and Sprague, **1923**), while the principle of types is not included in the international code, yet it is not opposed to the principles of that code and may be well applied along with it. This attitude seems to be generally

held by many European and American botanists of either School, and it is probable that the principle of types and provisions for determining types will be adopted at some future "International Botanical Congress."

In applying the principle of types (Bull. Torrey Club **34**: 167–178) to the case in hand we find that both *Ciboria* and *Sclerotinia* have priority over *Rutstroemia*, that the type species of *Rutstroemia* is found to belong to an older genus *Ombrophila*, that the other species should be transferred to either *Ciboria* or *Sclerotinia*, and that Karsten who created *Rutstroemia* has himself abandoned the genus. However, it has been customary in the past for mycologists to retain the abstract idea of a genus even though all binomial species including the type may be found to be incorrectly described and therefore transferred to another genus or to other genera. This principle, however, is contrary to the type-concept, and instead of retaining the abstract idea of a genus or species, which was incorrectly described, and therefore a description of something which in reality never existed, in which to place any species which might later be found to conform to it, the genus is rejected because it is not so associated with a species previously or simultaneously published. In addition to Karsten (**1885**), Saccardo (**1884** and **1889**), Boudier (**1885** and **1907**), Phillips (**1887**), Cook (**1892**) and Schröter (**1893**) did not recognize the genus *Rutstroemia* as valid. Rehm (**1887–1894**) apparently finding that *Ciboria firma* (Pers.) Fuckel (**1869**) had been included in the original list under *Rutstroemia* by Karsten and also finding that it differed from the other species in ultimately possessing at maturity a septation of the ascospores, modified the original limits of *Rutstroemia* Karst. to include only those species (otherwise similar to *Ciboria*) possessing 2- to 4-celled ascospores. Lindau (**1896**) and Durand (**1900**) have apparently followed Rehm in this particular. To the writer the genus *Rutstroemia* Karst. seems to be nonvalid for the following reasons:

(1) The type species (*R. bulgarioides* (Rab.) Karst.) of *Rutstroemia* has been shown to be a member of another older genus (*Ombrophila*).

(2) Although *R. firma*, which had previously been included in

Ciboria by Fuckel, was one of the species listed (last) under *Rutstroemia*, yet it is not the type species.

(3) The original description of *Rutstroemia* Karst. agrees with *R. bulgarioides* (Rab.) Karst., its type species, in having 1-celled ascospores.

(4) *Rutstroemia firma* and any other species possessing ascospores of more than one cell, included under *Rutstroemia* Karst. by Rehm or others, do not agree with the original generic description of *Rutstroemia*, and, therefore, the genus *Rutstroemia* has no binomial representing it which is in harmony with the original description, whereas the genus *Rutstroemia* Karst. as recognized and amended by Rehm calls for 2- and 4-celled ascospores. All representatives meeting with the original description of Karsten have been removed, due to priority, to the genera *Ciboria* and *Sclerotinia*.

It would seem to the writer that if a group, such as Rehm separated from *Ciboria* Fuckel on the basis of the septation of the ascospores, is worthy of recognition, a new generic name other than that of *Rutstroemia* Karst. should be used.

The type species of *Stromatinia* is *S. Rapulum* (Bull.) Boud. The exact nature of the sclerotium is difficult to determine from the literature. Bulliard (**1798**: *Pl. 485, fig. 2*) illustrated three apothecia but no attachment. Cooke (**1879**: *Pl. 50, fig. 197*) figured four complete apothecia and two in longitudinal section but no attachment. Persoon (**1801**: 658–659) and Fries (**1822**: 59) did not mention the attachment. All the above named authorities spoke of long filiform, tortuous stipes, deeply embedded in the ground and among leaves, which no doubt accounted for the failure to either find or illustrate the attachment. The older authorities may have failed to see the importance of the substratum. Boudier (**1905–1910**: **3**: *Pl. 478*) illustrated the apothecia attached to a rhizome which greatly resembles that of our common Solomon's seal, *Polygonatum biflorum* Walt. and *P. pubescens* (Willd.) Pursh. In volume four of his "Icones," Boudier (**1905–1910**: **4**: 277–278) stated that *Stromatinia Rapulum* (Bull.) Boud. had no sclerotium but arose directly from the rhizomes of *Polygonatum multiflorum* or *P. vulgare* which it rotted and replaced by a black and fragile stroma. Boudier

apparently had the idea of a stroma enveloping the organs upon which it was developed, but one not differentiated into a definitely shaped separate structure or sclerotium. Whether this stroma was a mixture of host and fungous tissues or was merely a layer of pure fungous tissue developed upon the surface of the rotted host is not so clear from the description. The writer, during the spring of 1925 collected a *Sclerotinia* occurring upon the rhizomes of *Polygonatum pubescens* (Willd.) Pursh. in Cascadilla Gorge, Ithaca, New York. The apothecia strongly resemble those of *Stromatinia Rapulum* (Bull.) Boud. and it is the opinion of not only the writer, but others, that this is the same fungus Durand described as *Sclerotinia Smilacinae*, mistaking the host, *Polygonatum*, for *Smilacina racemosa*. Durand stated (**1902**: 462) that the sclerotia were small, 1–2 mm. in diameter, irregularly spherical, aggregated and sometimes coalesced into a thin crust-like mass, 1–2 cm. in diameter. This crust-like mass may be of a nature similar to the stroma to which Boudier referred. As it is not a pseudosclerotium but really an aggregation of small true sclerotia, it appears to the writer that *Stromatinia* may be synonymous with *Sclerotinia* Fuckel, in the restricted sense. In fact it is possible that *S. Smilicinae* Durand is the same species as *Stromatinia Rapulum* (Bull.) Boud. The writer has not had an opportunity to study *Stromatinia Rapulum* (Bull.) Boud. to determine the exact nature of its stroma, but it is hoped that this may be done in the near future. Of the remaining species placed in the genus *Stromatinia* by Boudier, possibly half are known to possess pseudosclerotia and monilioid imperfect stages. These will be discussed later.

We still have to deal with the genera *Ciboria* Fuckel and *Sclerotinia* Fuckel. The presence of the sclerotium separates the latter from *Ciboria* in which the apothecia arise directly from a mycelium in the absence of a sclerotium. DeBary (**1887**: 499) defined a sclerotium as a "pluricellular tuber-like reservoir of reserve material forming on a primary filamentous mycelium from which it becomes detached when its development is complete, usually remains dormant for a time and ultimately produces shoots which develop sporophores at the expense of the reserve material." This is the type of structure found in all the

first four species originally included by Fuckel (**1869**: 330) in the genus *Sclerotinia*. There is no doubt that the true sclerotium, that is, a sclerotium composed entirely of fungous tissue, not a mixture of host and fungous tissue (pseudosclerotium, Atkinson **1905**), was the concept on which Fuckel based the genus *Sclerotinia*. The etymology of the name indicates that this is the important structure. Now it is easy to conceive of gradients all the way from the true sclerotial type to the simpler types, included in *Ciboria*, in which the apothecia arise from a mycelium having no apparent sclerotia. Among these intermediate stages would fall the group which at a later date Woronin and others included within the genus *Sclerotinia*. But at either end of the line of development, either between the forms with a pseudosclerotium and those with a true sclerotium or between the forms with a pseudosclerotium and merely a mycelium, it is possible for intergrading forms to occur. This structure is homologous throughout the group regardless of the form or composition it may assume. To the writer, the phylogenetic importance of the presence or absence of the sclerotium, which is merely the one extreme of a stromatic gradient possessed by a group of fungi exhibiting a very close relationship by the similarity of the external and internal characters of their apothecia, should not be given undue significance. It has served as a convenient, though possibly not a definite, means of designating certain groups of fungi. Now that our knowledge has extended to other species this means of separation is less satisfactory and we are more nearly able to judge relationships. Thus, for example, Fuckel created two groups, *Ciboria* and *Sclerotinia*, not being acquainted with members of a third group which later became known and which Woronin (**1888**) and Schröter (**1893**) included in the genus *Sclerotinia* and which some later authors have included in *Stromatinia* along with other species. It will be noticed that this division of genera made by the older mycologists and followed by the later ones is based solely on the stromatic stage. The understanding of their day did not permit of any other criterion in designating the genera. Our knowledge of the life-histories of these individual species is still comparatively meager. But gradually details of the life-history

of various members of *Sclerotinia*, *Ciboria*, etc., have accumulated, due to the researches of Woronin, Brefeld, von Tavel and others, so that at present we have a much clearer idea of this group. In this group, whose ascigerous fructifications arise directly from a mycelium, a pseudosclerotium or a true sclerotium, there are at least three characters in common, namely, the apothecium, microconidia, and mycelium. Von Tavel (**1892**: 105) has remarked about the presence of these same characters in this group of fungi. Members within the group differ principally by the absence or presence or by the type of the macroconidial stage. And again, von Tavel as early as 1892 (pp. 105–106) separated the genus *Sclerotinia* into subgroups on the basis of the conidial stage. He referred to one group as having given rise only to microconidia, a second group as having produced a *Botrytis*-like conidial stage (he apparently supposed *Botrytis cinerea* to be the conidial stage of *Sclerotinia Fuckeliana*) and a third group as having possessed besides microconidia, chlamydospores (he mentioned *S. baccarum* and *S. Vaccinii*).

The external characters of the apothecia of these three groups, as has been mentioned by Boudier (**1907**) and others, are so nearly alike that they are almost indistinguishable unless their attachment is known. Even with their attachment it is often difficult to determine to which group they belong until after a very careful examination. Durand (**1900**: 463) has studied thin sections of the apothecium of members of this group and used the internal characters of the sterile layers of the cup as important distinguishing characters to separate the fleshy Pezizineae. He used these internal structures to separate the different families. From this work it seems, therefore, that not only the exterior but also the internal morphology of the apothecium is indistinguishable in the three groups under discussion. Microconidia are present in all three groups. It is unnecessary to discuss the nature, morphology, and rôle of the microconidia here; but let it suffice to say that they correspond precisely, in all three groups, so far as known, in regard to general shape, size, internal and external characters and method of being borne. The next character to consider is that of the attachment. It is a vegetative structure. In *Ciboria* this structure may be indi-

cated as loose vegetative mycelium for, according to the concept of Fuckel, the apothecia arise directly from the host, or substratum from a mycelium which is not aggregated in the substratum. This is probably the simplest type of apothecial attachment. Then under the concept of the sclerotium as used by Woronin (**1888**) with the species of *Sclerotinia* occurring on *Vaccinium* or by Aderhold and Ruhland (**1905**) in their description of *Sclerotinia laxa*, *S. cinerea* and *S. fructigena*, we have a pseudosclerotium. In this we have a mycelium invading the outer tissues of the substratum and so permeating the tissue as to be a compact mass of both host and fungous tissue. To a somewhat similar structure in the genus *Balansia* Atkinson (**1905**) has applied the term *pseudosclerotium*. An important and almost constant character of these so-called pseudosclerotia, found in the fruit inhabiting species of *Sclerotinia*, is a definite blackened layer (cortex or rind) of heavy pseudoparenchymatous cells which form a protective layer on all exposed surfaces (both inner and outer) of this compact mass of host and fungous tissue. The interior (medulla) of these pseudosclerotia is as a rule whitish, the same as we find in a true sclerotium except for the dead host cells included. As the writer will show in the monographic paper, referred to above, he considers the pseudosclerotium in this group to be commonly comparable and analogous (probably homologous) to the entostroma usually recognized in the stromatic Sphaeriales. In the third group (Eusclerotinia) we find the mycelium in the form of a compact mass of pure fungous tissue such as is defined as a sclerotium by DeBary. The structure is essentially the same, namely *mycelium*, which is merely modified to meet the needs of the fungus or to comply with the restrictions placed upon the fungus by the host plant. That species which normally produce true completely differentiated sclerotia of pure fungous growth, may also have a mixture of host tissue as well as the pseudosclerotia is quite possible. *Sclerotinia sclerotiorum* and *S. Trifoliorum* oftentimes form sclerotia within the partially excavated chambers in the pith of their host plants and it is possible that they envelop cells of the host plant occasionally. Boudier (**1907**: 13) stated that one might very often find cells of the host plant, cells which had

been enveloped by the mycelium with the sclerotia, and cited specifically the case of *Sclerotinia Curreyana* with the sclerotia of which the star-shaped cells of the pith of the host were quite generally found. It appears evident, however, that inclusions of host cells within the sclerotia in this group of *Sclerotiniae* is purely an accidental phenomenon and not the constant typical condition characteristic of most of the fruit inhabiting group which form typical pseudosclerotia. The sclerotium is nothing more than a vegetative mycelial structure (stroma) which grades into a pseudosclerotium and into a loose vegetative mycelium on the one hand and a true sclerotium on the other. It is commonly believed that the function of the sclerotia is to produce apothecia. Since sexuality is assumed to be present in the apothecia arising from these sclerotia, the tendency has been to assign too great a significance to the sclerotium as a structure itself, rather than to the mycelium composing it. The fundamental function of the sclerotium is a vegetative food storage organ which is capable of overwintering or undergoing adverse conditions. In the genus *Ciboria* we have apothecia arising direct from a loose mycelium, sclerotia being absent, so there is no reason to ascribe a peculiar sexual nature to the vegetative, mycelial structure known as a sclerotium. The mycelium in the case of *Ciboria* apparently is capable of overwintering, undergoing the environmental and seasonal vicissitudes and of securing sufficient nourishment for apothecial production without the formation of a special reserve food supply and protective coating such as the typical sclerotium offers. Even Boudier has inferred that it was the function of the sclerotium to give rise to apothecia, but it does not seem to the writer that the sclerotium, as a structure, should be emphasized in a consideration of sexuality but rather the mycelium which is present in *Ciboria*, *Stromatinia*, or *Sclerotinia* regardless of whether the sclerotium or pseudosclerotium is present. A further discussion of the nature of the sclerotium and pseudosclerotium in the genus *Sclerotinia* will be given in the monographic paper soon to appear.

Thus we see that while sclerotia are present in certain members of this group of fungi now placed in *Ciboria*, *Stromatinia*, *Rutstroemia* or *Sclerotinia*, depending upon the authority, yet they

are not indispensable since they are entirely lacking in other species. Nevertheless, the sclerotium has been used in the past and it would seem out of question to ignore this structure entirely in taxonomy at present. Recognition must be given to the fact that, if the presence or absence of the sclerotium is used as a means of separating groups, there are marginal forms which might be of doubtful nature. This may be emphasized because of great variation within even a single species, as in the following example. The writer has collected specimens of *Sclerotinia Smilicinae* Durand which would appear to belong to *Ciboria* on the basis of manifest sclerotia. The apothecia appeared to arise directly from the rotted rhizomes, no sclerotia being evident. This is explained, however, by the fact that the sclerotia in this species are extremely small and were imbedded within the rotted rhizomes. Cultures from ascospores of this same collection gave rise to a multitude of small black sclerotia in and on the potato glucose agar. Under certain conditions the small sclerotia may aggregate and form a crust over the diseased rhizome and give the impression of a stroma. It would appear, therefore, that in order to show phylogeny and to arrange these species most satisfactorily for taxonomic purposes, the type of the attachment, whether loose mycelium, pseudosclerotium, true sclerotia or otherwise, should be supplemented by other structures produced during the life-histories of the fungi.

We still have to consider the imperfect stages occurring in the life-history of members of this group. Complete life-history studies are relatively few. There are many gaps, therefore, which research will need to fill in. However, on the basis of our present knowledge we have made a substantial start in this direction, thanks to the work of Woronin, Brefeld and others. Brefeld and von Tavel (**1891**: 318) stated that the ascospores of *Ciboria bolaris* Batsch and *Ciboria firma* Pers. in culture developed only a sterile vegetative mycelium except for the microconidia which were present in both. The writer also has cultured several species of *Ciboria* including *C. Caucus* (Rebent.) Fuckel and *C. amentacea* (Balb.) Fuckel with results similar to those of Brefeld and von Tavel. In nature, upon the proper host plant or substratum, these species might develop a typical

macroconidial stage; but if such occurs it is not known. It is probable that most of the species correctly attributed to *Ciboria* in the sense of Fuckel have no macroconidial stage but merely develop vegetatively into mycelium which is either scant in some species or very luxurious in other species. Certain members which Boudier placed in *Stromatinia*, for example *Stromatinia Rapulum* (Bull.) Boud. and probably *S. Paridis* Boud. and others, also lack a macroconidial stage, producing only the microconidia and the otherwise sterile vegetative mycelium, so far as known. Also certain members included by Fuckel in his genus *Sclerotinia*, as for example *S. Candolleana*, *S. Libertiana*, *S. tuberosa*, and others since placed in *Sclerotinia*, as *S. Smilicinae* Durand and *S. minor*, etc., would fall into this category. Thus we find within the various groups, based upon the absence or presence or type of sclerotium, that a subgroup may be arranged based upon the absence of a macroconidial stage.

Another group of species, included among those under consideration, has been definitely connected with macroconidial stages. The greater number of these forms are those whose imperfect stage falls in the Hypomycetous genus *Monilia* Pers. The conidia of this group are hyaline or light colored, ovate to lemon-shaped and borne in chains, commonly known as monilioid chains. Disjunctors between the conidia are common in many species while in others these structures are absent. Among species possessing this imperfect stage may be listed *Sclerotinia baccarum*, *S. Vaccinii*, *S. fructicola*, *S. laxa*, and others to be dealt with in the forthcoming monograph. Other Hyphomycetous conidial stages have been definitely connected with the apothecial stages of members of *Sclerotinia* Fuckel, for example, Seaver and Horne (**1918**) described a species of *Sclerotinia* with a *Botrytis*-like stage. This has been termed a *Botrytis*-like stage, because, while the general shape of the conidiophore and the conidium is that of *Botrytis*, the conidium instead of being smooth becomes quite strongly roughened, and because there may be other minor differences. This is the only species known to have this type of imperfect stage but it is closely related to *Botrytis*, and a *Botrytis* stage has been connected up with *S. Ricini* Godfrey (**1919**). Thus *Sclerotinia Geranii* Seaver &

Horne and *S. Ricini* Godfrey might form another group or groups with botrytioid or pseudobotrytioid conidia. A *Penicillium*-like type of conidial production has been described by Maul (**1894**) and Rostrup (**1897**) for *Sclerotinia Alni* Maul. This may form still another division on the basis of the imperfect stages although there is some doubt regarding this point and it may even constitute nothing more than the microconidial stage. Possibly further observations and researches will add new members to the groups already indicated and add other types of imperfect stages which are at present unknown.

Thus we have reviewed briefly the general conditions now known to exist in that group of fungi, designated by Fuckel (**1869**) under the genera *Ciboria* and *Sclerotinia*, by Karsten (**1871**) under *Rutstroemia* and later (**1885**) also under *Ciboria* and *Sclerotinia* and by Boudier (**1907**) under the tribe Ciboriées (which includes *Ciboria*, *Stromatinia* and *Sclerotinia*). In the present state of our knowledge regarding this group of fungi a complete and final diagnosis would be premature at this time. Such a diagnosis of the genus *Sclerotinia* is being undertaken by Professor H. H. Whetzel.

To the student of the fungi reviewed above, it is apparent that the forms dealt with and recognized as properly belonging to this group are closely related. In fact they so intergrade that a sharp line of demarcation cannot be drawn between certain groups of them. Therefore there may be the tendency on the part of certain workers to merge those forms, which Boudier (**1907**: 105) included within the tribe Ciboriées, into one genus in a manner somewhat similar to that of Karsten when he created the genus *Rutstroemia*. If this procedure were followed in dealing with this group of *Peziza*-like fungi, *Ciboria* would have priority, and if one genus were recognized, *Ciboria* Fuckel would necessarily be the valid name to apply. Such a merging of these closely related forms is, however, not the tendency among modern mycological workers, and it appears to be untenable at present. This group of fungi appears rather to represent a subfamily, as Boudier (**1907**) has treated them, or a distinct family. The writer believes that the genera *Ciboria* and *Sclerotinia* should be recognized as distinct genera and that

the genus *Sclerotinia* as it is now recognized should be subdivided into either subgenera or genera on the basis not only of the nature of the stroma but also of the type of conidial fructification, grouping those forms which appear to be most clearly related phylogenetically. Genera should show phylogenetic relationships as nearly as possible, yet they are at best little more than arbitrary units. In this group of fungi the picture or configuration of the individual species or of genetic concepts is not complete or adequate when considering but one stage, such as, for example, the stromatic stage, exclusive of the apothecial or the conidial stages.

In the present paper we are not concerned directly with the disposition of other members of the genus *Sclerotinia* outside of the monilioid forms. For this reason we shall proceed to a discussion of a disposition of the monilioid species of *Sclerotinia*.

In the monographic paper which is to be published later the morphologic structures of taxonomic value which are present among the monilioid species of *Sclerotinia* will be more completely discussed. These structures of taxonomic significance are chiefly the following: the pseudosclerotium, the apothecium (including rhizoidal tufts), the conidial stage, and the microconidia.

CONCLUSIONS

A careful consideration of the morphological structures which are present among the monilioid species of *Sclerotinia* impresses one with the striking unity of this taxonomic subgroup. All of the members referred to the group show unmistakable evidence of close relationships, at least, closer relationship to each other than to the other members now included within the genus *Sclerotinia* and not possessing the monilioid conidial stage. It is reasonable and logical to believe that a typical *Sclerotinia* even though it may possess a pseudosclerotium and at the same time a distinct type of macroconidial stage, such as *Botrytis*, is not as closely related to each and every species of *Sclerotinia* possessing a pseudosclerotial stage and a monilioid stage as those monilioid species are to one another. The intercalation of other conidial types into the same group with the monilioid species of *Sclerotinia* breaks up the unity of the group and does not represent a natural

classification. It does not assist in the expression of phylogeny, which should be the aim of taxonomy.

Life-history studies bring out the great unity of this monilioid group in a manner much more convincing than the mere statement of the presence of certain structures such as a pseudosclerotial and a monilioid conidial stage. Other structures and physiological activities show the close relationship and unity within the group. Examples of this are blossom infection, leaf infection and mummification of fruits. All known species are virulent pathogenes giving rise to the same general type of disease symptoms (necroses). In general the individual species are believed to have a very narrow host range, *Sclerotinia fructicola*, *S. laxa* and *S. fructigena* being the greatest exceptions to this rule.

The monilioid group exhibits specialization among its members in varying degrees and different directions as would be expected among evolving organisms in a dynamic world where variation is the dominant feature and as is commonly observed in other groups and genera. Because of the lack of certain data it is difficult to trace phylogenetic tendencies in close detail but the general trend may be indicated. Thus we may consider certain species within this group as more primitive, others as more advanced morphologically and physiologically.

The question arises as to what characters are more primitive and what more specialized, and which species represent each group. It is not the purpose of this paper to answer this question for the entire group at present included within the genus *Sclerotinia*, but it would appear that *Ciboria* is more primitive than any species included in *Sclerotinia*. We might use *Ciboria*, therefore, as a starting point. Here a loose nourishing mycelium constitutes the vegetative phase; a conidial stage, so far as known, is absent. Next in rank we place those forms developing pseudosclerotia—a mixture of host and fungous growths, followed by a still more specialized stroma, the true sclerotium. Within the monilioid species of *Sclerotinia*, therefore, those forms approaching more nearly to the true sclerotial condition might be regarded as more specialized. Of the monilioid species, the Rosaceae-inhabiting group, in general, probably shows the least

specialization of the pseudosclerotium (PLATE 18). More host tissue is retained within the pseudosclerotium, and its organiza-

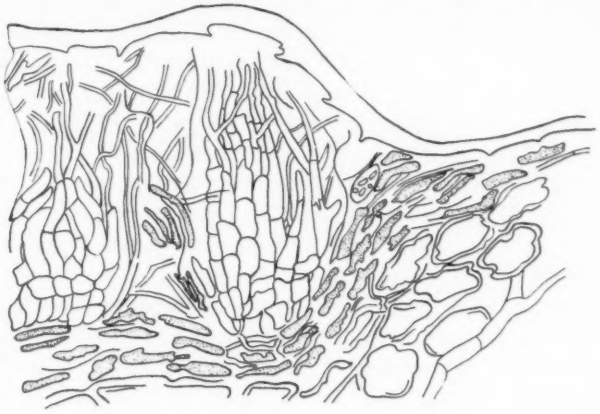


FIG. 1. Ectostroma in diseased fruit.

tion is not so definite as in the *Vaccinium*-inhabiting group. A definite ectostroma is present within the diseased fruit and

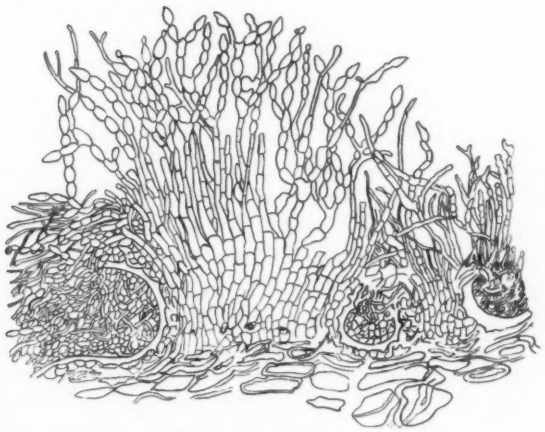


FIG. 2. Developing conidia.

commonly functions in rupturing the surface of the diseased organ and in giving rise to the conidial stage (FIGS. 1 AND 2).

Greater specialization is shown in the pseudosclerotium of the *Vaccinium*-inhabiting species and even within this group a marked advance is to be noted. Here, the pseudosclerotium consists largely of fungous growth. Cross-sections show the arrangement of the hyphae to be more nearly like that found in true sclerotia. Islands of host tissue surrounded by fungous growth are more conspicuous than the uniform presence of host tissue throughout the pseudosclerotium, as found in *S. fructicola*, for instance. The tendency is strikingly toward a more thoroughly organized fungous body. Another striking advance is the apparent tendency to segregate the conidium-producing ectostroma from the apothecium-producing entostroma and the suppression of the functioning of the ectostroma in the diseased fruit. The entostroma develops quite rapidly and the ectostroma becomes included within the entostroma, disappears or at least becomes unable to rupture the surface of the fruit and produce the conidial fructifications. Here the production of conidia is restricted for the most part, at least, to infections resulting from ascospores on shoots and leaves. Segregation and specialization are taking place. It may be considered a step toward the heteroecism described by Woronin and Nawaschin (**1896**) in *Sclerotinia Ledi* (= *S. heteroica*) and by Fischer (**1925**) in *S. Rhododendri*. The next step in specialization is represented first by the solid pseudosclerotium, then by the heteroecism as found in *S. Ledi* and *S. Rhododendri* which gives a still more complete segregation of the conidial production to one host and sclerotial and apothecial production to another host. Even a further step in pseudosclerotial development, though not accompanied by heteroecism, has been described by Schellenberg (**1907**: 200–201) for *Sclerotinia Ariae*, in which he stated that the pseudosclerotium was of pure fungous tissue with very few inclusions of dead host cells brought about by the development by the fungus of a closed ring, which as it grew pushed the dead tissue of the fruit equally inward and outward. He even described some small true sclerotia of this fungus being developed on the pedicels. This species would then appear to constitute the climax in the development of the pseudosclerotium within this group and indicate a border-line form with the true sclerotium producing groups.

Other structures have either developed or degenerated along with the evolution of the pseudosclerotium. It is possible that the monilioid conidial fructification which we have stressed as being so very characteristic in this group may have arisen from such a form as represented by *Sclerotinia Alni*, which while lacking a conidial stage nevertheless has a pseudosclerotial stage formed within the fruit of its host. On the other hand, such species (as represented by *S. Alni* and *S. Betulae*) might be considered as representing degenerate forms. This is mere supposition on the part of the writer who has not studied intensively the species belonging to this group of *Sclerotiniae*. It may be desirable to include such forms as primitive monilioid species of *Sclerotinia*, but this can be determined only by a further study and consideration of the group. Even such a form as the *Sclerotinia* developing from the pseudosclerotium of *Sclerotium bifrons* cannot be overlooked entirely. Could not this form which develops a typical composite sclerotium or pseudosclerotium within the leaves of *Populus* spp. also be a primitive monilioid form? On the basis of the presence of a pseudosclerotium alone, such a disposition would be possible, but the writer is not, at present, in a position to give his final opinion on this point. A fuller discussion of the possible basis for including these forms within the monilioid group of *Sclerotiniae* will be given in the monograph. It is possible that these two last mentioned representatives can best show phylogeny by being retained as a distinct unit or units to show relationships with other groups of the *Sclerotinia* family. Therefore, while these latter forms have not been included within the monograph, referred to, the writer does not exclude them from this group of fungi.

The monilioid species of *Sclerotinia* are apparently less specialized morphologically than the botrytioid group. This conclusion is arrived at, first because of the presence of a true sclerotium in the botrytioid forms, and secondly, because of the manner of development of the conidia themselves. Botrytioid conidia are definitely, highly developed, typical conidia, formed on well developed and differentiated conidiophores. Monilioid conidia, as found in this group, are less highly specialized. In fact

Brefeld (**1891**: 317) did not consider the macroconidia in the monilioid species of *Sclerotinia* as true conidia but rather as chlamydospores, probably due to the acrogenous elongation and formation of the chain of spores and the intercalary development and the existence of primary and secondary walls. Von Tavel (**1892**: 106) also used the term chlamydospore for these spores. However, the writer considers the so-called chlamydospores as true conidia but representing a somewhat less specialized type than those of *Botrytis*. The occurrence of disjunctors within this group would indicate a further specialization in a different direction than that taken by *Botrytis*. Thus it may be concluded that the group of monilioid species of *Sclerotinia* here considered is more or less intermediate between forms possessing a loose vegetative mycelium only, but lacking a conidial stage, and those possessing a true sclerotium and a definite typical conidial stage, such as *Botrytis*. Species possessing pseudosclerotia as well as true sclerotia may lack a macroconidial stage, but they are apparently the more primitive members in their respective groups.

The distinctive characteristics of the monilioid species of *Sclerotinia* are, first, the presence of the pseudosclerotium, and second, the monilioid conidial stage. Because of its distinct unity and harmonious conformity in representing natural relationships this group is regarded as of generic rank. As shown in an earlier part of this paper the original concept of the genus *Sclerotinia* included only those forms possessing a true sclerotium. Because of the great similarity of the apothecia and the failure to recognize the significance of the pseudosclerotium, the monilioid forms along with many other divergent forms in the past have been included within the genus *Sclerotinia*. As pointed out in the historical review, no other previously proposed generic or subgeneric name or concept is valid for this group, and therefore, the writer suggests the name *Monilinia* to embrace this new genus of monilioid species of *Sclerotinia*. The name, *Monilinia*, is derived from *Monilia* (= plural of Latin *Monile* = necklace), the genus to which the characteristic conidial stage has commonly been referred. Concerning the status of the genus *Monilia* see Vuillemin (**1911**) and Berkhout

(**1923**). Not all members at present included in the genus *Monilia* are referable to *Sclerotinia* and included as the conidial stages of *Monilinia*, as might be expected in a form-genus not based upon a natural classification.

TECHNICAL DESCRIPTION

Monilinia gen. nov.

Sclerotinia Fuckel (*pro parte*) Schroeter, Krypt.-Fl. Schlesien **3**: 63–67. 1893.

Stromatinia Boudier (*pro parte*) Hist. Class. Discom. Eu. 108. 1907.

Monilia Pers. emend. Saccardo (*pro parte*) Michelia **2**: 17. 1882.

Monilinia fructicola (Winter) comb. nov.

Apothecia small to moderately large, solitary to very many, developing from overwintered, more or less specialized composite stroma (entostroma) or pseudosclerotium which is commonly formed within the fruits of its respective hosts, closed at first, opening into a funnel- then cup-shape, sometimes becoming flat or recurved, commonly with a narrow even margin, with more or less elongated, straight or bent stipes, exterior smooth, waxy, light or dark brown, more or less hairy, especially toward the base, with or without rhizoidal tufts; asci cylindrical-clavate, somewhat thickened and rounded at the apex, with the tip or the pore frequently staining blue with iodine, eight-spored; spores elongate or ellipsoidal, ends pointed or rounded, straight or but slightly curved, unicellular, commonly possessing one to several oil-drops, guttulae, or refractive spots, generally hyaline, rarely dark, obliquely uniseriate, frequently becoming subbiseriate; paraphyses simple or branched near the base, thread-like, septate, commonly more or less swollen at or toward the upper end, hyaline; hypothecium and excipulum distinct, prosenchymatous, generally with a pseudoparenchymatous outer layer; conidial stage common on young leaves, on shoots, on fruits, on twigs or limb cankers of the host plant; conidiophores commonly arising either from a well developed, effuse septate mycelium or ectostroma, or frequently from clustered ectostroma which ruptures the epidermis of the host organ, forming light ochre to ash grey or dark olivaceous colored sporodochia composed of more or less elongate, erect, simple or di- or trichotomously branched conidial chains; conidia (macroconidia) ellipsoidal, elongate-ellipsoidal to limoniform, rarely spherical, gen-

erally hyaline or light colored, developed acrogenously in chains upon the more or less short conidiophores, commonly separated by disjunctors or lacking these; microconidia commonly present, small, spherical, hyaline, generally containing one (more rarely two) large, round, refractive granule, borne directly or upon short clavate microconidiophores.

The type species, *Sclerotinia fructicola* (Wint.) Rehm, is the brown-rot fungus of orchard fruits commonly occurring in eastern North America and first described by Winter, from

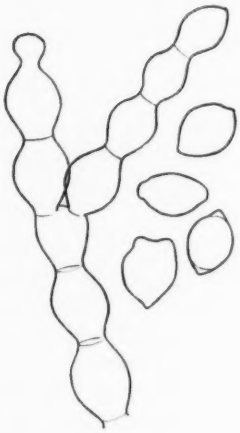


FIG. 3. Conidia.

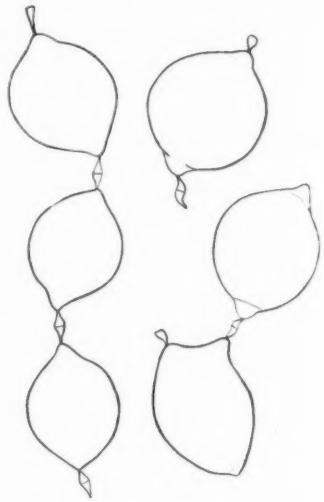


FIG. 4. Conidia.

material of the perfect stage collected by Eugene A. Rau at Bethlehem, Pennsylvania, as *Ciboria fructicola*. Type material of this species has not been seen by the writer but cotype material has been examined. The cotype material is deposited in the Eugene Rau Collections in the Office of Pathological Collections of the United States Department of Agriculture, Washington, D. C.

Typical apothecia of this species, cross-sections of the pseudosclerotium and the conidial stage are shown in PLATES 17, 18, and 19 respectively. The two types of monilioid conidial fructifi-

cations found in this genus are represented in FIGURES 3 AND 4. FIGURES 1 AND 2, adapted from Sorauer (**1899**), illustrate the development and structure of the ectostroma and of the conidial fructification in certain members of the genus *Monilinia*.

SUMMARY

An historical review of the closely related genera *Ciboria* and *Sclerotinia* is given.

The non-validity of the genera *Rutstroemia* and *Stromatinia* has been discussed.

Type species for these four genera have been designated following the principle of types as outlined in the American code of botanical nomenclature.

A basis for the classification of the genus *Sclerotinia*, as recognized up to the present, is indicated.

A new genus, *Monilinia*, is created to include the monilioid forms which show a genetic relationship to the genus *Sclerotinia*. *Monilinia fructicola* (Wint.) Honey (= *Sclerotinia fructicola* (Wint.) Rehm) is designated as the type species of the genus *Monilinia*.

The writer wishes to express his appreciation to the various individuals to whom he has been indebted during the preparation of this article: to Professor Whetzel for the suggestion of the problem of which this is an outgrowth; to Dr. L. M. Massey for the photographic privileges of the Department of Plant Pathology of Cornell University; to Dr. C. L. Shear for the privilege of examining the cotype material; to Dr. E. M. Gilbert, Dr. G. W. Keitt, Dr. A. J. Riker and Dr. Regina Stockhausen Riker for the critical reading of the manuscript; and to Dr. Fred J. Seaver for kindly suggestions concerning the manuscript.

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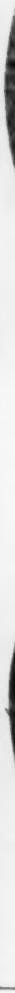
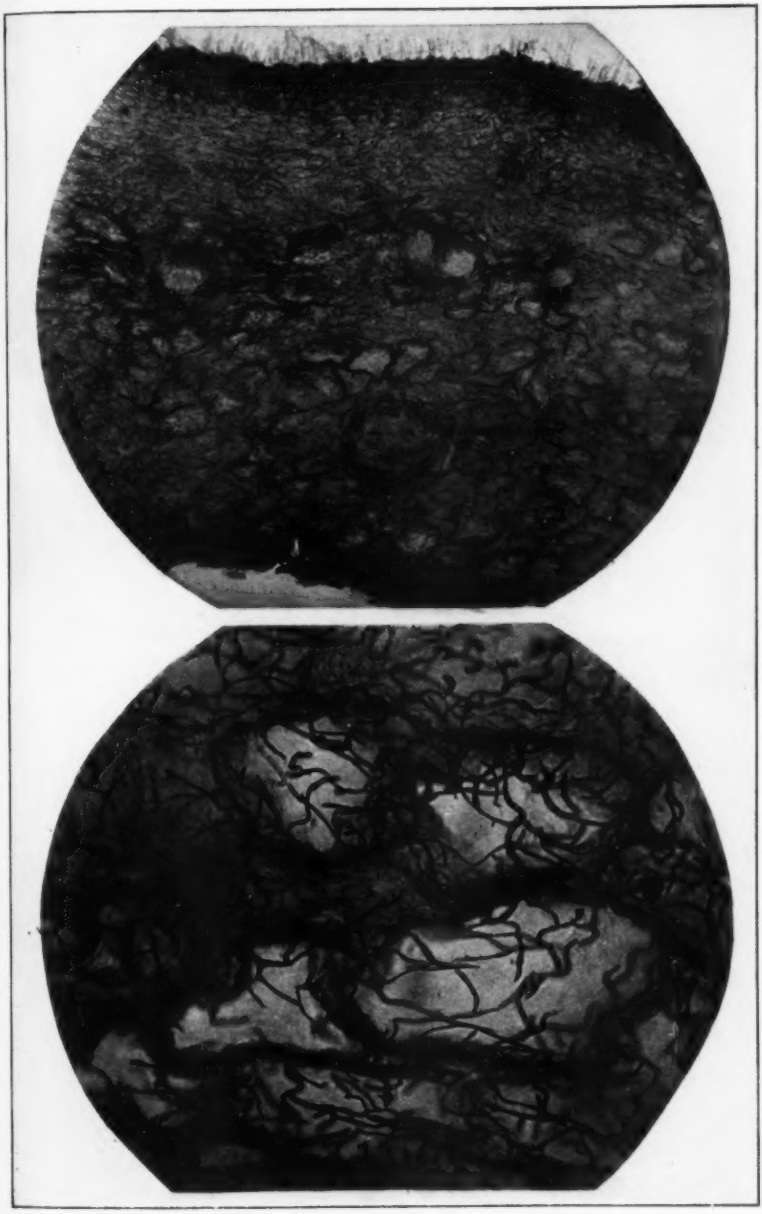
MONILINIA FRUCTICOLA





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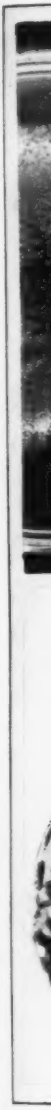

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EXPLANATION OF PLATES

PLATE 17

Apothecia of *Monilinia fructicola* (Wint.) Honey on mummied peach fruits. Upper, immature apothecial fundaments in various stages of development; lower, mature apothecia (natural size).

PLATE 18

Photomicrograph of a free-hand cross-section (stained) through a portion of a pseudosclerotium of *Monilinia fructicola* (Wint.) Honey formed within the pericarp of cultivated peach fruit. Upper, showing above the black pseudoparenchymatous rind developed beneath the epidermis of the fruit upon which may be seen the typical trichomes; below the similar black pseudoparenchymatous rind which has separated the pseudosclerotium from the inner pulp of the fruit. Between these two outer coats lies the white fungous medulla intermixed with the brown dead collapsed host cells. Lower, a small portion of the above section showing in greater detail the host tissue and the fungous hyphae.

PLATE 19

Conidial fructification of *Monilinia fructicola* (Wint.) Honey. Top left, 4-day-old petri dish culture; top middle, 8-day-old culture; top right, 4-day-old test-tube culture (all cultures on potato glucose agar held at 24° C.); bottom, natural infection on pear fruits. All artificial cultures are of strain H 441, isolated from ascospores from apothecia produced on peach mummies. (All figures about 4/5 natural size.)

CONTRIBUTIONS TO OUR KNOWLEDGE OF WESTERN MONTANA FUNGI—II PHYCOMYCETES

PAUL W. GRAFF

The present contribution appears in continuation of previously published notes [1] on western Montana fungi. The earlier paper was confined to a consideration of the Myxomycetes gathered in that region. The present is restricted to the group of the Phycomycetes. It might well be called a "preliminary report" for there is no doubt that continued study devoted to these forms would reveal much of interest, and many more species than have been included here. The diversity of species listed, and the comparatively untouched condition of the field, is sufficient warrant for this assumption.

CHYTRIDINEAE

FAMILY 1. OLPIDIACEAE

1. OLPIDIUM PENDULUM Zopf, in Schenk's Handb. **4**: 555, *pl. 66*. 1890.

On pollen grains of *Pinus ponderosa* Dougl., Rattlesnake Creek, vicinity of Missoula, Missoula County, May 9, 1920, at about 4,000 feet elevation.

This species appeared attacking pollen grains gathered with an algal collection and kept in laboratory cultures. The parasitized pollen was in sufficient quantity for comparison, and to leave no doubt as to the identity of the fungus. As is usually the case with this species, the sporangia seen in the different grains were quite variable in both size and number. The zoöspores measured about 5 μ in diameter, and were almost spherical in form. No resting sporangia were seen.

[1] Graff, Paul W., Contributions to our Knowledge of Western Montana Fungi—I. MYCOLOGIA **20**: 101–113. 1928.

FAMILY 2. WORONINACEAE

2. OLPIDIOPSIS SAPROLEGNIAE (A. Br.) A. Fisch. in Rabenh. Krypt.-Fl. 1^4: 38, *fig. 4.* 1892.

Chytridium Saprolegniae A. Br. Phys. Abh. Acad. Wiss. Berl. **1855**: 61, *pl. 5, fig. 23.* 1855 (in part).

Olpidiopsis Saprolegniae (A. Br.) Cornu, Ann. Sci. Nat. Bot. V. **15**: 145, *pl. 3, fig. 1–9.* 1872 (in part).

Growing upon *Saprolegnia monoica* Pringsh., from Yellow Bay Creek, University of Montana Biological Station grounds, east shore of Flathead Lake, July 8, 1918, at about 3,000 feet elevation.

In this collection the resting spores appeared typical, and very closely approximated in size those described by Fischer, measuring 65–70 μ in diameter, or 65 $\times$ 75 μ when ellipsoidal in shape. The surface in this species is covered with coarse warting, and we find attached, in many cases, an "anhangszelle" of approximately half the diameter of the resting spore. *Chytridium Saprolegniae* of Braun has been found to be separable into two distinct species. In these we find the vegetative development somewhat confusing, but their resting spores offer no difficulties. In the case of *Olpidiopsis Saprolegniae* (A. Br.) A. Fisch., they vary from spherical to slightly ellipsoidal, and are strongly warted, while in *Pseudolpidium Saprolegniae* (A. Br.) A. Fisch. they are decidedly ellipsoidal, distinctly spinose, and somewhat larger. This latter species has thus far not been collected in Montana.

FAMILY 3. RHIZIDIACEAE

3. RHIZOPHIDIUM AMPULLACEUM (A. Br.) A. Fisch. in Rabenh. Krypt.-Fl. 1^4: 101. 1892.

Chytridium ampullaceum A. Br. Phys. Abh. Acad. Wiss. Berl. **1855**: 66–67, *pl. 5, fig. 24–27.* 1856.

Parasitic on *Oedogonium crenulato-costatum* Wittr., Yellow Bay Creek, between Yellow Bay and Bear Trap Mountains, Mission Range, Lake County, July 23, 1918, at about 4,500 feet elevation; on *Mougeotia* sp., marsh south of Finley Point, Flathead Lake, July 22, 1921, at about 3,000 feet elevation;

on *Oedogonium plagiostomum* Wittr., Rattlesnake Creek, above Greenough Park, vicinity of Missoula, September 26, 1925, at about 3,600 feet elevation.

The zoösporangia of this species are spherical, 7–8 μ in diameter, with a penetration tube through the host wall, but with no well-developed rhizoids. Discharge of zoöspores is through a cylindrical tube-like opening from the apex, similar to but slightly longer than that of *Phlyctochytrium equale* Atk., in fact the portion of that plant developed as sporangium outside the host appears very similar to *Rhizophidium ampullaceum* in both size and form. The tube in the case of *R. ampullaceum* is 4–5 μ long by 2 μ in diameter, while in *P. equale* it is of the same diameter but only 1.5 μ in length. The presence of this tube-like exit for the zoöspores forms a striking difference between this species and the other members of the genus reported here, most of which seem to have distinctive features in the manner of providing for spore escape.

Peterson (**1910**) says that this species should be transferred from the Chytridineae to the Infusoria. He gives no reason for this conclusion, and without some convincing evidence to the contrary, the logical position for this fungus seems to be in the Rhizidiaceae.

4. RHIZOPHIDIUM GLOBOSUM (A. Br.) Schröt. Krypt.-Fl. Schles. **3**: 191. 1886.

Chytridium globosum A. Br. Phys. Abh. Acad. Wiss. Berl. **1855**: 34–39, *pl. 2, fig. 14–20.* 1856.

Parasitic on diatoms gathered in a surface towing among *Scirpus lacustris* L., in marsh south of Finley Point, Flathead Lake, July 22, 1921, at about 3,000 feet elevation.

The sporangia of this species are spherical, measuring 25–40 μ in diameter, and the largest of the several members of this genus reported here. The zoöspores escape through a large terminal opening which is not raised, and as a consequence the spherical form of the zoösporangium is maintained even after maturity and spore discharge. The rhizoids are quite reduced and similar in development to those of *Rhizophidium sphaerocarpum* (Zopf) A. Fisch.

5. RHIZOPHIDIUM POLLINIS (A. Br.) Zopf, Abh. Naturf. Ges. Halle **17**: 79–107. 1887.

Chytridium pollinis Pini A. Br. Phys. Abh. Acad. Wiss. Berl. **1855**: 40–41, *pl. 3, fig. 1–15*. 1856.

Chytridium vagans A. Br. Monats. Berl. Acad. **1856**: 588. 1856.

On gymnospermous pollen gathered with an algal collection from Yellow Bay Creek, between Bear Trap and Yellow Bay Mountains, Mission Range, July 7, 1920, at about 3,600 feet elevation; on pollen of *Pseudotsuga mucronata* (Raf.) Sudw., gathered and placed in an algal culture from Yellow Bay Creek, University of Montana Biological Station grounds, east shore of Flathead Lake, July 11, 1921, at about 3,000 feet elevation.

Zoösporangia spherical to ovoid, 20–35 μ in diameter, with well-developed rhizoids ramifying through the host cell. One to several irregularly located openings are formed for the escape of the zoöspores instead of the usual single apical aperture. These openings are not raised or papillate, and are scarcely broader than the diameter of the zoöspores, being nearly round in form and measuring about 5 μ in diameter.

6. RHIZOPHIDIUM SPHAEROCARPUM (Zopf) A. Fisch. in Rabenh. Krypt.-Fl. **1**[4]: 95. 1892.

Rhizidium sphaerocarpum Zopf, Nova Acta Leop.-Carol. Akad. **47**: 202, *pl. 19, fig. 16–27*. 1884.

Parasitic on *Mougeotia sphaerocarpa* Wolle, in a collection of various algae from Estey's Pond, vicinity of Bigfork, Lake County, July 7, 1921, at about 3,000 feet elevation; on *Mougeotia* sp., gathered in a swamp on Finley Point, east shore of Flathead Lake, July 22, 1921.

Sporangia ovoid, 12–16 $\times$ 14–20 μ, becoming thistle-shaped with dehiscence through a single, proportionately large, circular, apical opening 4–6 μ in diameter, with either very much reduced rhizoids or contact with the interior of the host cell limited to merely a penetration tube without rhizoidal development. This species illustrates the intergradation of such forms as have been placed in the genus *Phlyctidium* and those similar in form but producing a rhizoidal development.

7. PHLYCTOCHYTRIUM EQUALE Atk. Bot. Gaz. **48**: 338, *fig. 8.* 1909.

On *Spirogyra Spreeiana* Rabenh., collected among other algae in a swamp on the south side of Finley Point, east shore of Flathead Lake, July 22, 1921, at about 3,000 feet elevation.

Phlyctochytrium is related to *Rhizophidium*, but differs from that genus in the development of a swollen or bulbous base of the penetration tube immediately within the wall of the host cell. The delicate rhizoids are produced from the lower portion of this subsporangial base. In this species both basal and exterior portion are of equal size, measuring 5–7 μ in diameter. The zoöspores escape through a terminal opening which has the form of a short tube.

This opening is described by Atkinson (**1909**) as being round and having two small tooth-like projections on either side. These projections, shown in his figure of the species, are the side walls of the short tube. This cylindrical tube measures 2 μ in diameter and 1.5 μ in length.

As no partition wall is formed between the portions of this fungus outside and within the host, and as the content of the two portions appears to be used in the formation of zoöspores and is completely discharged at their maturity, it seems that we have here what is really a dumbbell-shaped sporangium neither wholly outside nor inside the host. This suggests that it is not improper to consider the members of this genus as representing intermediate forms between the genus *Rhizophidium* with its typically exterior sporangia and the genus *Entophlyctis*. In the latter genus the remnant of the fungus remaining on the exterior of the parasitized cell is seen as a papilla which serves later as a zoöspore exit, while the portion entering the host enlarges to form a sporangium. From the surface of this zoösporangium the rhizoids of the fungus are produced.

No such method of zoöspore escape as described by Petersen (**1910**) for *Phlyctochytrium stellatum* was suggested by the material of this collection which acted always in a manner typical for the genus.

FAMILY 4. HARPOCHYTRIACEAE

Gobi (**1899**) is of the opinion that the genus *Harpochytrium* (*Fulminaria*) belongs among the stalked flagellates, while Wille (**1900**) places it among the algae, though believing it to be composed of reduced forms adapted to a saprophytic existence. In so doing he proposes the family Harpochytriaceae for its accommodation. Though standing more or less apart from the other genera, mycologists, as a rule, have disposed of this genus among the Rhizidiaceae. In this Gäumann (**1926**) concurs, but he considers it of totally independent origin from the other members of this family. Having very little in common with the Rhizidiaceae, it seems better that these forms be set apart, at least until some sufficient diagnostic character appears to entitle them to a place in a family already established. In so doing the use of Wille's name for the family is naturally retained, transferring it from the original position among the algae to one near the Rhizidiaceae. With this change the following emended diagnosis is suggested.

Plants nonchlorophyllaceous, fusoid, slightly curved or coiled, stalked or sessile, epiphytic, attached by a small disk-like basal expansion to the wall of the supporting plant, unicellular prior to maturity, later divided by a thin transverse wall into a sterile vegetative base and a zoösporangium. The zoöspores escape through the apex, after which the sterile base may grow upward filling the empty sporangium and the process of septation be repeated, successive sporangia being formed by proliferation much as in *Saprolegnia*. The zoöspores are uniflagellate, with the flagellum attached to the smaller forward end, somewhat irregular in shape, one side tending to be straight or slightly concave, hence swimming with a very erratic movement. The type species of the family is *Harpochytrium Hyalothecae* Lagerh.

8. HARPOCHYTRIUM HEDENII Wille, in Peterm. Mitteil. Erg. 371. 1900.

Fulminaria Hedenii Wille, Nyt. Mag. Naturvid. **41**: 175. 1903.

Rhabdium acutum Dang. Ann. Myc. **1**: 61–64, *pl. 2*. 1903.

On *Zygnema insigne* (Hass.) Kütz., Yellow Bay Creek, Uni-

versity of Montana Biological Station grounds, east shore of Flathead Lake, Lake County, July 11, 1921, at about 3,000 feet elevation; on *Zygnema* sp., Bitterroot River, vicinity of Missoula, Missoula County, May 23, 1925, at about 3,500 feet elevation.

Plants elongate, fusoid, slightly curved to one and a half times coiled, varying from 5–6 × 75–150 μ, tending to taper more prominently toward the base than apex. The plant is attached by a small disk-like expansion within the wall of the host, but not penetrating completely to the interior of the cell; hence, seemingly not in contact with the cytoplasm. This disk serves as a holdfast, and from it no rhizoids develop. This characteristic makes the fungus, to all appearances, an epiphyte rather than a parasite. The Montana material is thus in full agreement with Atkinson's (**1903**) description of this species. On the other hand, Dangeard (**1903**) considers that the fungus penetrates to the interior of the host cell, and develops the disk in contact with the cytoplasm. Lagerheim (**1890**) suggests that there are probably rhizoids extending from the disk-like base into the host cell. This has never been substantiated by other observers, and is no more than surmise on his part.

A further point of disagreement is connected with sporangial development. As the plant proceeds toward maturity the greater portion of the cytoplasm, variable in amount and constituting anywhere from three-fourths to five-sixths of the upper part, assumes a more dense appearance than the remainder. While the zoöspores are being formed in this upper portion, the lower part is cut off by a thin wall, thus creating at maturity a vegetative and a reproductive portion from what up to that time showed only a unicellular structure and the presence of vegetative activity. After the escape of the zoöspores from the apex, the lower sterile portion of the plant may grow upward within the empty sporangium till nearly filling it, when the process of separation into zoösporangium and sterile base is repeated. This proliferation frequently takes place two or three times. Here again we are in agreement with Atkinson as well as, in this instance, with Lagerheim.

Dangeard claims that after the complete emptying of the sporangium, formed from the entire plant, a new sporangium

may be developed within the old, suggesting a possibility of rejuvenation. Obviously this is an impossibility unless growth is provided for by a remnant of cytoplasm or by the method Gobi suggests. Gobi (**1899**) claims for *Harpochytrium Hyalothecae* Lagerh. (*Fulminaria mucophila* Gobi), a closely related species, that there is no sterile portion remaining after the zoöspores have escaped, but that if a zoöspore remain behind it may germinate there and develop a new sporangium, or plant, within the old, and so give the appearance of proliferation. Due to the epiphytic, rather than parasitic, nature of the members of this genus it is obviously not impossible for a chance zoöspore to develop in this manner. The condition is unusual, however, and Gobi seems to be the only one to report its occurrence. It is also not inconceivable that at times the entire content of the cell might be transformed into zoöspores. In this event no further growth could take place and no secondary zoösporangia could be formed, unless some such occurrence as Gobi mentions should take place. At the end of the growth period for a plant, after the last proliferation has taken place, either the entire cytoplasm is used in the development of zoöspores or the sterile base dies and growth ceases. Following this a chance zoöspore might easily remain in the lower portion of the otherwise empty sporangium, develop there, and produce a new plant within the old. Gobi's observations are neither impossible nor illogical so far as they go. The trouble is that he did not follow the plants through as extended or as careful a series of observations as he should. A sterile basal area has been described as characteristic of *H. Hyalothecae* Lagerh., *H. Hedenii* Wille, and *H. intermedium* Atk., the three recognized species of the genus, and so for the entire membership of the family.

FAMILY 5. RHIZOPHLYCTACEAE

9. POLYPHAGUS EUGLENAE (A. Br.) Nowak. in Cohn, Beitr. Biol. Pflanz. **2**: 203, *pl. 8–9*. 1876.
Chytridium Euglenae A. Br. Phys. Abh. Acad. Wiss. Berl. **1855**: 46. 1856.

Parasitic on *Euglena viridis* Ehrenb., vicinity of St. Ignatius, Lake County, June 28, 1920, at about 3,000 feet elevation; same host and locality, June 25, 1921.

Euglena viridis Ehrenb. is especially plentiful in the numerous glacial pot holes of the region immediately north of the town of St. Ignatius. There is a recurrence each season, at approximately the time these collections were made, of a sufficient number of the organisms to form a complete scum over the surface of many of these ponds. The water is warm and, with evaporation taking place, a considerable deposit of *Euglena* in the encysted condition is left about the muddy margin. *Polyphagus* was not uncommon among the floating material, and its recurrence under the prevailing conditions may be expected. In fact at the time of the collections cited above, the attack by this fungus might be considered of epidemic proportions.

10. SPOROPHLYCTIS ROSTRATA Serb. Scripta Bot. Hort. Univ. Imp. Petrop. **24**: 164–165, *pl. 1–2, fig. 13–35*. 1907.

On *Draparnaldia plumosa* (Vauch.) Agardh, Yellow Bay Creek, between Yellow Bay and Bear Trap Mountains, Mission Range, July 23, 1918, at about 4,000 feet elevation.

This very interesting little fungus seems to have been reported heretofore only by Serbinow in the description of his original collection made in the vicinity of St. Petersburg. In the Montana material akinet formation was observed essentially as described by Serbinow, but conjugation between individuals and developments depending upon it were not seen. Though a number of other collections were made in the same locality with the hope that the various stages of development might be reviewed, the parasite only appeared in the one.

FAMILY 6. CLADOCHYTRIACEAE

11. **Cladochytrium maculare** (Wallr.) comb. nov.

Physoderma maculare Wallr. Fl. Crypt. Germ. **2**: 192. 1833.

Protomyces macularis (Wallr.) Sacc. Michelia **1**: 13. 1879, non Fuckel.

Cladochytrium Alismatis Büsgen, in Cohn, Beitr. Biol. **4**: 280. 1887.

On *Alisma brevipes* Greene, collected in a swamp on the south side of Finley Point, east shore of Flathead Lake, July 22, 1921.

The present collection records a new host as well as a new locality for this fungus. Previously the species has only been reported as attacking *Alisma Plantago* L., in Europe and the eastern United States, and *Alisma subcordata* Raf., in Manitoba. *Protomyces macularis* of Fuckel (**1869**) seems to be synonymous with *Doassansia Alismatis* Cornu. There is no doubt, however, that *Physoderma maculare* Wallr. is the *Cladochytrium Alismatis* of Büsgen, and of this collection. Wallroth's original specimens were examined and well figured by DeBary (**1864**). Büsgen in making the transfer from *Physoderma* to *Cladochytrium* changed the specific name as well, apparently with no other reason or intent than to have the specific name conform with that of the host. This change has been perpetuated by all later workers who have had occasion to cite this species. Adherence to the rules of priority makes necessary the use of Wallroth's rather than Büsgen's specific name.

12. UROPHLYCTIS ALFALFAE (Lagerh.) Magn. Ber. Deuts. Bot. Ges. **20**: 291–296, *pl. 15*. 1902.

Cladochytrium Alfalfae Lagerh. Bull. Herb. Boissier **3**: 53–74. 1895.

Causing crownwart of cultivated *Medicago* sp., vicinity of Polson, Lake County, July 15, 1921.

Though not uncommon to the westward this seems to be the first collection of this parasite reported from Montana. The disease has been considered common only west of the Sierra Nevada and Cascade Mountains. O'Gara has reported the trouble in the Salt Lake Valley of Utah, and McCallum has reported it as present in Arizona, thus carrying the range eastward in the south and central west. The present collection extends the range of the disease eastward from its more northern habitat in Oregon and Washington, though still failing to carry it beyond the Rockies in this section.

13. UROPHLYCTIS PLURIANNULATUS (Berk. & Curt.) Farlow, Rhodora **10**: 12–13. 1908.

Uromyces pluriannulatus Berk. & Curt. Grevillea **3**: 57. 1874.

Uromyces hemisphaerica Speg. Anal. Soc. Ci. Argent. **12**: 26. 1881.

Urophlyctis Kriegeriana Magn. Sitzber. Ges. Naturf. Freu. Berl. **1888**: 100. 1888.

Urophlyctis hemisphaerica (Speg.) Syd. Ann. Myc. **1**: 517–518. 1903.

On leaves of young plants of *Osmorrhiza longistylis* (Torr.) DC., vicinity of Yellow Bay, Flathead Lake, July 10, 1920.

This seems to be a new host as well as a new locality for this fungus. Both leaf blades and their petioles were found to be attacked. Small pustules are formed, the surface of which becomes granular in appearance and of a yellow color. With age this color changes to brownish. The effect on the host simulates much the appearance of a rust, and accounts for the errors in the earlier determinations. Farlow (**1908**) recognized the mistake of Berkeley and Curtis, and also the fact that *Urophlyctis Kriegeriana* Magn. is synonymous with this species. Sydow (**1903**) recognized the identity of *U. Kriegeriana* with Spegazzini's species of *Uromyces*, but failed to note these as the same fungus Berkeley and Curtis had described at an earlier date.

OOMYCETINEAE

FAMILY 7. LAGENIDIACEAE

14. MYZOCYTIUM PROLIFERUM Schenk, Contr. Zellen 10. 1858.

Pythium proliferum Schenk, Verh. Phys.-Med. Ges. Wurzb. **9**: 20. 1857, non DeBary.

Lagenidium globosum Linds. Synop. Saproleg. 54. 1872.

Parasitic in cells of *Cladophora Kuetzingiana* Grunow, Rattlesnake Creek, Greenough Park, Missoula, September 23, 1919; in *Zygnema cruciatum* (Vauch.) Agardh, marsh south of Finley Point, Flathead Lake, July 22, 1921.

Vegetatively this plant forms a rudimentary hypha or pseudohypha of irregularly arranged somewhat ovoid or ellipsoidal cells. These are transformed later into zoösporangia within which the biflagellate zoöspores are developed; or adjacent cells may conjugate and a resting spore be formed in one of each conjugating pair. In the closely related *Lagenidium* we find the antheridial cell much smaller than that in which the oöspore is developed. *Myzocytium* does not show as much differentiation. The

antheridial and oögonial cells are, superficially at least, indistinguishable from one another till the formation of the oöspore presents a distinguishing mark.

15. LAGENIDIUM RABENHORSTII Zopf, Verhandl. Bot. Vereins. Prov. Branden. **20**: 77. 1878.

Attacking vegetative cells of *Spirogyra orthospira* Nag., in an algal collection from Estey's Pond, vicinity of Bigfork, Lake County, July 1, 1921; within cells of *Oedogonium plusiosporum* Wittr., in a collection of miscellaneous algae, marsh south of Finley Point, Flathead Lake, July 22, 1921.

The antheridia of this species are formed as short cells cut off in the vicinity of the irregular, long, swollen oögonial cells with which they conjugate by means of a short penetration tube. The oöspores are spherical, measuring 15–20 μ in diameter.

FAMILY 8. BLASTOCLADIACEAE

16. BLASTOCLADIA RAMOSA Thaxter, Bot. Gaz. **21**: 45–52, *pl. 3, fig. 1–16*. 1896.

On submerged sticks of *Populus trichocarpa* T. & G., shore of Yellow Bay, Flathead Lake, July 12, 1919; on submerged sticks of *Betula fontinalis* Sarg., in a quiet pool of Yellow Bay Creek, east shore of Flathead Lake, July 1, 1921, at about 4,500 feet elevation.

From the rhizoidal base the plant develops a single stalk of uniform diameter, and of about half the height of the plant. From this stalk numerous branches develop in a somewhat irregular subdichotomous manner. The branched head of the plant has a breadth of from 250 to 550 μ; very rarely this is greater and may reach a diameter of 650 μ. On the ends of the branches, or slightly below, zoösporangia or conidia are developed, both of nearly the same size and shape. The conidia are broadly ovoid, 11–15 $\times$ 30–32 μ, rounded at the apex and truncate at the base. The zoösporangia are likewise broadly ovoid, 12–16 $\times$ 30–32 μ, bluntly pointed or broadly papillate at the apex and truncate at the base. The conidia possibly partake more of the nature of resting spores though their walls are not heavy, being in fact but very slightly thicker than those of the zoösporangia.

FAMILY 9. LEPTOMITACEAE

17. SAPROMYCES REINSCHII (Schröter) Fritsch, Österr. Bot. Zeits. **43**: 420. 1893.

Naegeliella Reinschii Schröter, in Engler & Prantl, Nat. Pfl. 1[1]: 103, *fig. 85.* 1897.

Rhipidium elongatum Cornu, Ann. Sci. Nat. Bot. V. **15**: 15. 1871.

On submerged twigs of *Pseudotsuga mucronata* (Raf.) Sudw., Yellow Bay, east shore of Flathead Lake, July 12, 1919.

The plant seems to be attached to the substratum directly by its lower segment which may become somewhat distorted but does not produce a definite rhizoidal development. The vegetative portion is characteristically constricted with some regularity, and has the appearance of segmentation which in reality may or may not occur. Branching is profuse, and the plant spreading. Either zoösporangia, oögonia, or antheridia may be produced at the upper ends of the segments, whether terminal or not, and most often in whorls of from two to five. At times zoösporangia and oögonia or zoösporangia and antheridia are found associated, though in no case were oögonia and antheridia seen to be developed in the same whorl.

FAMILY 10. SAPROLEGNIACEAE

18. SAPROLEGNIA DICLINA Humph. Trans. Am. Phil. Soc. **17**: 109, *pl. 17, fig. 50–53.* 1892.

Saprolegnia dioica DeBary, Bot. Zeit. **46**: 619, *pl. 10, fig. 12–13.* 1888, non Pringsh., non Schröter.

On fly larvae placed in a mixed algal culture from Yellow Bay Creek, University of Montana Biological Station grounds, east shore of Flathead Lake, Lake County, July 1, 1921.

Oögonia, while not numerous, were produced in the culture. These varied from 50–75 μ in diameter, and had from 7–16 egg cells developed in each. Antheridia were in evidence wherever oögonia were present. In this association they were numerous and almost completely covered the oögonia, in which they form a conspicuous characteristic for this species.

19. SAPROLEGNIA MONOICA Pringsh. Jahrb. Wiss. Bot. **1**: 292, *pl. 19–20.* 1858.

Achlya intermedia Bail, 35te Versamml. Deuts. Naturf. Aerzte Konigs. **1860**: 5. 1861.

Diplanes saprolegnioides Leitg. Jahrb. Wiss. Bot. **7**: 374, *pl. 24.* 1869.

On flies in a culture of *Vaucheria sessilis* (Vauch.) DC., kept in the laboratory, from Yellow Bay Creek, University of Montana Biological Station grounds, east shore of Flathead Lake, July 8, 1918; on flies placed in a mixed algal culture dredged from Yellow Bay, Flathead Lake, July 16, 1921.

This species has been reported previously by Atkinson (**1897**) from Alabama, and by Pieters (**1915**) from Michigan. It is evidently of much more frequent occurrence in Europe than in the United States. The Montana material corresponds closely with the characteristics of the species rather than with either var. *glomerata* Ties., or var. *vexans* Pieters, which have been reported as more common in this country. The wide separation of the three habitats for the species would seem to indicate the possibility that further study will give more prominence to this form of the fungus than it has formerly received. In the Montana material the oögonia were in the usual racemose form, and associated with these were antheridial branches of the androgynous type. Oöspores were found to number from 5–14 in an oögonium, rarely more, and measured 16–20 μ in diameter. Zoösporangia were slender, cylindrical to clavate, and frequently found proliferating.

20. SAPROLEGNIA PARASITICA Coker, The Saprolegniaceae, 57–59, *pl. 18, fig. 1–12.* 1923.

From a diseased spot on the side of a large fish of the sucker variety caught in Yellow Bay, Flathead Lake, July 28, 1921.

The fish, weighing about three pounds, was so sluggish in its actions that it was easily snagged with a bare hook and brought to the surface. The diseased spot on its side was somewhat over an inch in diameter, discolored, somewhat darker than normal in the center with a lighter margin. Macroscopically the disease appeared to penetrate for about half an inch, though undoubtedly actual penetration into the flesh was much deeper.

21. ISOACHLYA MONILIFERA (DeBary) Kauff. Am. Jour. Bot. **8**: 231. 1921.

Saprolegnia monilifera DeBary, Bot. Zeit. **46**: 629–631, *pl. 9, fig. 6.* 1888.

On flies placed in a mixed algal culture from Rattlesnake Creek, Greenough Park, Missoula, September 26, 1925; on flies in culture jar with *Spirogyra* sp., from Bitterroot River, vicinity of Lolo, Missoula County, May 12, 1926, at about 3,500 feet elevation.

Oögonia appeared very abundantly, in chains, individuals varying considerably in size, 45–80 μ in diameter, but with the greater portion about 60 μ. No antheridia were seen. Zoösporangia were relatively few in number, moderately long, with their greatest breadth well toward the tip. Growth was quite profuse.

22. ACHLYA AMERICANA Humph. Trans. Am. Phil. Soc. **17**: 116, *pl. 14, fig. 7, 9, 10.* 1892 [1893].

On submerged decaying sticks of *Populus trichocarpa* T. & G., Yellow Bay, east shore of Flathead Lake, July 12, 1919; on submerged sticks of *Alnus tenuifolia* Nutt., in warm slough from the Bitterroot River, near Ft. Missoula, vicinity of Missoula, May 17, 1925.

This species seems to approach very closely to *Achlya DeBaryana* Humph., from which it differs in having short-stalked oögonia with many more pores in their walls and smaller oöspores. Petersen (**1910**) considers this a variety of what he calls *A. polyandra* (Hildebr.) DeBary, as in his opinion *A. polyandra* Hildebr., and *A. polyandra* DeBary, are synonymous. In this combination Petersen fails to find support. *A. polyandra* DeBary is *A. DeBaryana* Humph., DeBary's name being antedated by that of Hildebrand, while *A. polyandra* Hildebr. is recognizd as a distinct species known to DeBary and named by him *A. gracilipes*. The former of these is not recognized as an American species. The latter has been found occasionally in this country. If *A. americana* Humph. is to be considered as a variety, it should be not as Petersen suggests but as *Achlya DeBaryana* Humph., var. *americana* (Humph.).

23. ACHLYA RACEMOSA Hildebr. Jahrb. Wiss. Bot. **6**: 249–269, *pl. 15–16.* 1867.

On flies in a mixed algal culture from Yellow Bay Creek, Biological Station grounds, east shore of Flathead Lake, July 17, 1918; on flies in a culture of *Zygnema* sp., from Estey's Pond, vicinity of Bigfork, Lake County, July 26, 1919; on flies placed in a culture of *Spirogyra orthospira* Nag., from Estey's Pond, July 1, 1921.

In this material the oögonia were formed on short lateral branches. They showed a variation of from 45–70 μ in diameter, with 60 μ the more usual size. Antheridial branches arise from a position on the oögonial stalks immediately below the oögonia. There are usually but one or two of these antheridia to each oögonium, though occasionally there are more.

FAMILY 11. PERONOSPORACEAE

24. ALBUGO BLITI (Biv.-Berhn.) O. Kuntze, in Magn. Abh. Natur. Ges. Nürnb. **11**: 53. 1897 [1898].

Uredo Bliti Biv.-Bernh. Stirp. Sicula Manip. **3**: 11. 1815.
Cystopus Bliti Lév. Ann. Sci. Nat. III. **8**: 371. 1847.

On *Amaranthus retroflexus* L., vicinity of Polson, Lake County, July 8, 1919; on the same host, vicinity of Bigfork, Lake County, July 17, 1920

25. PERONOSPORA EFFUSA (Grev.) Rabenh. Herb. Myc. **1**: 264. 1880.

Botrytis effusa Grev. Fl. Edin. 468. 1824.
Botrytis farinosa Fr. Syst. Myc. **3**: 404. 1829.

On leaves of *Chenopodium album* L., near road east shore of Flathead Lake, between the Biological Station and Bigfork, Lake County, July 7, 1919.

Conidiophores were hypophyllous, on the lower leaves of the host, causing them to turn yellowish at first, later brown, after which they ultimately dry, wither, and fall.

26. PERONOSPORA PARASITICA (Pers.) DeBary, Ann. Sci. Nat. Bot. IV. **20**: 110. 1863.

Botrytis parasitica Pers. Obs. Myc. **1**: 96, *pl. 5, fig. 6.* 1796.

On the lower leaves of *Cogswellia montana* (Coult. & Rose) Jones, Hell Gate Canyon, vicinity of Missoula, May 12, 1925; on *Cogswellia leptocarpa* (Nutt.) Jones, vicinity of Missoula, May 15, 1926; on *Cogswellia montana* (Coult. & Rose) Jones, Ft. Missoula, vicinity of Missoula, May 18, 1926.

The various species of *Cogswellia* are very generally infected with this disease in this region, and are consequently of importance as carriers of the fungus.

27. PERONOSPORA TRIFOLIORUM DeBary, Ann. Sci. Nat. Bot. IV. **20**: 117. 1863.

On leaves of cultivated *Medicago sativa* L., vicinity of Missoula, June 3, 1926; on same host, vicinity of Lolo, Missoula County, June 7, 1926.

So far as I am aware, this disease of our cultivated Alfalfa has been reported from Colorado, but not farther north in the Rocky Mountain region. The conidiophores were wholly confined to the under side of the leaflets which, as a consequence of the disease, showed a decided tendency to curl downward. The conidia measured 18–20 × 21–27 μ, not as wide a range in size as usually found, and not as large as the figures given by Stewart (**1908**) for the fungus as found in New York state. This New York material, however, according to Stewart, produces spores of greater dimension than the typical. Oöspores were not seen. This species is a very close relative of *Peronospora Viciae* Berk., from which it differs chiefly in the branching of the conidiophores. These branches form broad obtuse angles in *P. Trifoliorum* and acute angles in *P. Viciae*. The spores developed in either case are of the same size.

28. BASIDIOPHORA KELLERMANII (Ellis & Hal.) Wilson, Bull. Torrey Club **34**: 394–395. 1907.

Peronospora Kellermanii Ellis & Hal. in Ellis & Everh. N. Am. Fungi *2201.* 1889.

On *Iva xanthiifolia* Nutt., vicinity of Polson, Lake County,

July 8, 1919; also vicinity of Stevensville, Rivalli County, July 14, 1925, at about 4,000 feet elevation.

29. PLASMOPARA GERANII (Peck) Berl. & DeToni, in Sacc. Syll. Fung. **7**: 242. 1888.

Peronospora Geranii Peck, Rept. N. Y. State Mus. **28**: 63. 1874.

On leaves of *Geranium viscosissimum* F. & M., vicinity of Yellow Bay, east shore of Flathead Lake, July 14, 1920; on leaves of *Erodium cicutarium* (L.) L'Her., on the bank of Rattlesnake Creek, Greenough Park, Missoula, May 23, 1923.

30. PLASMOPARA OBDUCENS (Schröt.) Schröt. in Cohn, Krypt.-Fl. Schles. 1^3: 238. 1889.

Peronospora obducens Schröt. Hedwigia **16**: 129. 1877.

On *Impatiens aurella* Rydb., vicinity of Yellow Bay, east shore of Flathead Lake, July 6, 1921; on *Impatiens* sp., Lolo Creek, Missoula County, June 24, 1925, at about 4,200 feet elevation.

31. PLASMOPARA RIBICOLA Schröt. in Cohn, Krypt.-Fl. Schles. 1^3: 238. 1889.

Peronospora ribicola Schröt. Jahr. Schles. Gesell. **1883**: 179. 1883.

On wild gooseberry, Spring Gulch, Rattlesnake Valley, vicinity of Missoula, June 14, 1920, at about 3,600 feet elevation; on young plants of *Ribes* sp., on south side of Mt. Sentinel, Pattee Canyon, vicinity of Missoula, May 29, 1923, at about 4,500 feet elevation.

32. BREMIA LACTUCAE Regel. Bot. Zeit. **1**: 666, *pl. 3*. 1843.

Botrytis ganglioniformis Berk. Jour. Hort. Soc. Lond. **1**: 51. 1846.

Peronospora gangliformis DeBary, Ann. Sci. Nat. Bot. IV. **20**: 108. 1863.

On leaves of *Lactuca virosa* L., vicinity of Yellow Bay, east shore of Flathead Lake, July 3, 1918; on the lower leaves of *Lactuca Ludoviciana* (Nutt.) DC., vicinity of Polson, Lake County, July 12, 1921.

ZYGOMYCETINEAE

FAMILY 12. MUCORACEAE

33. ABSIDIA CAERULEA Bain, Bull. Soc. Bot. **1**: 184. 1889.

Appearing on bread in a laboratory culture, Missoula, February 19, 1918; also February 26, 1923.

34. MUCOR ABUNDANS Povah, Bull. Torrey Club **44**: 292–293, *pl. 17, fig. 1–6*. 1917.

On bread in a laboratory culture, Missoula, February 23, 1922; also February 20, 1925.

This species shows in its general appearance considerable resemblance to *Mucor hiemalis* Wehm., but differs in being decidedly racemose rather than usually unbranched, and in its pyriform instead of spherical to oval columella. The spores in both cases are nearly of a size, but differ in shape. In the case of *M. abundans* they are globose to subellipsoidal and measure 3–6 × 4–8 μ, most often globose and 3–5 μ in diameter. In *M. hiemalis* they are ellipsoidal or somewhat irregularly so, measuring 2–5.5 × 3–8.5 μ, with a usual size of 3 × 7 μ.

35. MUCOR CIRCINELLOIDES Van Tiegh. Ann. Sci. Nat. Bot. VI. **1**: 94. 1875.

On a bread culture, Missoula, February 19, 1918; also February 26, 1923, and February 20, 1925.

36. MUCOR MUCEDO (L.) Bref. Bot. Unters. **1**: 7, *pl. 1–2*. 1872.

Mucor Mucedo L. Sp. Pl. **2**: 1655. 1753, in part.

Mucor sphaerocephalus Bull. Hist. Champ. Fr. 112, *pl. 480, fig. 2*. 1791–98.

On bread culture, Missoula, February 19, 1918; also February 23, 1922, and March 2, 1923.

37. MUCOR PLUMBEUS Bonord. Abh. Naturf. Ges. Halle **8**: 109. 1864.

Mucor spinosus Van Tiegh. Ann. Sci. Nat. Bot. VI. **4**: 390. 1876.

On bread culture, Missoula, February 23, 1922, and February 20, 1925.

In this species we find a characteristic spinose development on the upper portion of the columella. *Mucor spinescens* Lend.

is undoubtedly a close relative if not a mere variation of the above. Their chief characteristics are decidedly similar though in the latter species the sporangiophores are reported as much shorter, 1 mm. instead of 1 cm., and the sporangia 60–68 μ instead of 100 μ in diameter. The spores in both cases are found to be spherical, and measure 5–8 μ in diameter. The case of *M. plumbeus* and *M. spinescens* is only one among the number to be found in the Mucoraceae where a critical study is needed to determine the identity or validity of species.

38. MUCOR RACEMOSUS Fres. Beitr. Mycol. **1**: 12, *pl. 1, fig. 24–35*. 1850.

Pleurocystis Fresenii Bonor. Allgem. Mycol. 124. 1851.

On bread culture, Missoula, February 19, 1918; also March 2, 1923, and February 20, 1925.

39. RHIZOPUS NIGRICANS Ehrenb. Nova Acta Leop.-Carol. Akad. **10**: 198, *pl. 11, fig. 1–7*. 1820.

Mucor stolonifer Ehrenb. Sylvae Myc. Berol. **13**: 25. 1818.

On bread culture, Missoula, February 19, 1918; also February 23, 1922, and February 26, 1923.

40. THAMNIDIUM ELEGANS Link, Observat. 45, *pl. 2, fig. 45*. 1809.

Mucor elegans Fries, Syst. Myc. **3**: 322. 1829.

Ascophora elegans Corda, Icon. Fung. **3**: 14, *pl. 2, fig. 43*. 1839.

Thamnidium elegans Van Tiegh. Ann. Sci. Nat. Bot. V. **17**: 321, *pl. 23, fig. 57–60*. 1873.

On bread culture, Missoula, February 23, 1922; also February 20, 1925.

FAMILY 13. PIPTOCEPHALIDACEAE

41. PIPTOCEPHALIS FRESENIANA DeBary, Abh. Senckenb. Naturf. Ges. **5**: 356, *pl. 43, fig. 17–19*. 1865.

Parasitic on *Mucor circinelloides* Van Tiegh., Missoula, February 26, 1923; also on *Mucor racemosus* Fres., Missoula, March 2, 1923, and February 20, 1925, all from bread cultures.

FAMILY 14. CHAETOCLADIACEAE

42. CHAETOCLADIUM JONESII (Berk. & Curt.) Fres. Beitr. Myc. 97, *pl. 12, fig. 5–12.* 1863.

Botrytis Jonesii Berk. & Curt. Ann. Mag. Nat. Hist. XIII. **2**: 760, *pl. 15, fig. 12.* 1854.

In bread cultures, parasitic on *Mucor abundans* Povah, and *Mucor Mucedo* (L.) Bref., Missoula, February 23, 1922.

FAMILY 15. ENTOMOPHTHORACEAE

43. EMPUSA MUSCAE Cohn, Nova Acta Leop.-Carol. Akad. **25**: 301–360, *pl. 9–11.* 1855.

Myiophyton Cohnii Leb. in Denk. Schw. Ges. Naturw. **15**: 26. 1857.

On dead flies, University of Montana Biological Station, Yellow Bay, July 2, 1921; on dead house flies, Missoula, August 29, 1925.

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